PRACTICAL ESSAYS.

BY

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CONTENTS.

EDINBURGH:
MACLACHLAN, STEWART, & COMPANY.

MDCCCXLI.

PREFACE.

The term of *Practical Essays* has been given to these, to distinguish them from the volume of papers, reprinted by the Author from the Transactions of the Royal Societies of London and Edinburgh.

The Author has entertained the belief, that a member of a University should watch the current opinions on the subject he teaches, and endeavour to check the wrong bias which fashion and accident are continually giving to Medical Studies, to the neglect of sound doctrine, and of approved authorities. If this be granted, no further apology will be necessary for these occasional Essays.

The professional friends who shall peruse these pages, will acknowledge that they treat of subjects of much difficulty, but embracing questions of practical importance; and they will not regret that their attention has been solicited to them.

Ainslie Place,
1st *February* 1841.

PRACTICAL ESSAYS.

ESSAY I.

ON THE POWERS OF LIFE TO SUSTAIN SURGICAL OPERATIONS THE EFFECTS OF VIOLENCE IN WOUNDS AND IN OPERATIONS: AND THE CAUSES OF SUDDEN DEATH DURING SURGICAL OPERATIONS IN SOME REMARKABLE INSTANCES.

THIS subject has been pressed on the author's attention by death occurring during operations with such appalling suddenness, that, before the operator could turn round, sense and motion had ceased. Such cases, though happily rare, demand examination, and ought to lead to a general survey of the causes of death. In importance it yields to no other question, and needs no apology.

The conviction comes tardily on the surgeon's mind, that there is a limit to his boldness and ingenuity in operating on the living body; hence it is that surgeons of experience refuse to do those feats which they were eager to perform in their younger days.

A change has taken place in the mode of education of surgeons since the time when Mr John Bell made his eloquent appeals to enforce the study of surgical anatomy. In this respect all has been attained, but there may be an error the other way. The young surgeon, by exercise in anatomy, acquires a workman's feeling of his subject, that every thing may be accomplished by dexterity; and he engages in operations which the powers of life cannot sustain.

Before treating of the main subject, which is death from the admission of air into the circulating system, I shall notice some of the more common causes of death, that we may be the better able to judge of the force of the objections which have been made to the possibility of this occurrence.

We cannot do better than take the method of Cullen, and consider the "direct" and the "indirect" causes of death; that is, the influences which act immediately on the nervous system, and those which destroy the organization necessary to the support of nervous excitement.

Syncope, or deliquium, seldom takes place during an operation. It is more frequent after it, when the patient is assured that the pain and danger are over. It is then an influence of the mind, as in fright and sudden joy, which suspends the heart's full action,

and diminishes the force of circulation in the brain. Originating in the brain, the cause happily ceases with the insensibility, and the patient revives. When there has been great loss of blood, fainting may be succeeded by death. The expression in common parlance for this sudden death is collapse,—a term once familiar to the learned, but then, as now, unintelligible; unless it means the action of the heart on an insufficient supply of blood [*ancæmasis*]. In effect this is equivalent to debility of the heart itself [*asthenia*, abattement], and both these causes combining make hæmorrhage in the dropsical and chlorotic very dangerous,—they faint and do not recover. I need hardly say, that to procure fainting, in order to save the infliction of pain during an operation, is unwarrantable. If the pain of the operation does not rouse the sufferer to consciousness, what will?

Severe and long continued surgical operations may be attended with fainting, as torture and grievous wounds are. We witness this in the reduction of dislocations; there is, however, in such cases, something peculiar in the nature of the pain, or rather in the part which suffers.

Death may be caused by direct injury to the nervous system. A severe blow on the stomach kills instantly. If a man, having fallen from a height, be

brought into the hospital dead, and there is neither rupture of a viscus nor injury of the head, he may have suffered from the general shock, as you kill an eel; or it may have happened, that he has struck the stomach against something in his descent, as I had, in one instance, reason to believe had taken place. We supposed that the man had, in his descent, been doubled over the iron of a lamp.

A blow on the throat has proved suddenly fatal. In this case, I believe that, as in the instance of death from a blow on the stomach, the injury is propagated to the source of the respiratory nerves, and hence the sudden interruption to breathing and expression, as well as motion of the body.

I remember to have seen a patient brought into the operating theatre, and, being placed on the table, he was dead! On inquiry, the case was peculiar and applicable. He had a shattered limb, and had suffered under tetanus. In this malady we may be deceived; for, after severe suffering for two days, it is not unusual to have a report that he is better, because of the relaxation of the spasm, and the capacity of swallowing; directly after which he sinks.

Fear of hæmorrhage has almost disappeared; and certainly a well educated surgeon, in cases of operation, will not let his patient die of bleeding. It may be reasonably imagined, that the quantity of blood

lost, being obvious to sight, would render the symptoms attending that loss of little importance; yet I have seen the surgeon greatly miscalculate the quantity of blood lost during an operation, and with fatal consequences. In internal hæmorrhage from deep wounds, from contusion, and bursting of the solid viscera, in uterine hæmorrhage, the symptoms are the only sources of alarm. When there is formidable bleeding during a protracted operation, the flow of blood stops, through exhaustion, to return in the evening; and when the pulse rises and the patient becomes hot and restless, it may then prove fatal.

The loss of blood, in every case, is attended with great thirst; there is an asthmatic sensation in the breast, which makes the patient sigh deeply;* he becomes ashy pale; the pupils are dilated; his sight fails; he is alarmed that he does not see his friend, and stares wildly; his hands are abroad, if not restrained; there is vertigo; his pulse is weak and compressible. Often, convulsions precede death (a sign alarming to the accoucheur). If there be a slow draining of blood, it is attended with a low delirium.

* And so it is when an animal is purposely bled to death: When the carotid is opened, and after the first burst, the breathing becomes hurried and laborious—the eye becomes heavy, and, before death, there is a general convulsion of the frame.

The patient on the operating table has died from a rupture of the great artery. The heart and vessels are in great excitement, when a man braces his courage to submit to an operation. Sir Astley Cooper sent me the aorta of a man who died under the operation for popliteal aneurism; and, if I remember right, the patient was carried out without the operation being completed.

If a limb be entangled in machinery and torn off; if the knee-joint be crushed; if a man receive the whole charge of a fowling-piece in his thigh, or has his limb carried off by a cannon shot, the effect will be immediate: he will be found pale, and cold, and without pulse; the countenance haggard, and the expression wild; and, in a low delirium, he sinks the same evening.

No one deserving the name of surgeon will place a patient on the operating table, when the respiration has partaken of this influence, and the chest rises high, or when the extremities are becoming cold; for these are the indications of approaching death.

The result of a surgical operation, severe and too long protracted, is similar to that of a grievous wound; as in lithotomy, when a large stone has caused difficulties and repeated unsuccessful efforts; or the operation for *fistula in perineo* too long per-

severed in. It may be, that in cases of lithotomy, lithotrity, and fistula, the part operated on, more than the degree of suffering, is the cause of symptoms. In the operations on the urinary organs with violence, the kidney suffers: the secretion of urine is suppressed; the urea, or a poison, circulates, and falls on the brain, and the patient becomes delirious, almost maniacal, in which state he dies. I have seen painful instances of the maniacal state from diseases of the urethra and bladder. The subject is now better understood, from the labours of Dr Bright, and is well touched upon by Professor Christison, in his work on the Granular Degeneration of the Kidneys.

But independently of the particular organ, we cannot witness great and protracted violence in surgical operations without apprehension that the powers of life will fail. When we see the limbs stiffened through agonizing pain; the face turgid, and the eyes prominent and suffused; when the patient faints through excess of suffering; and when, though insensible, the frame is still convulsed with hysterical heaving of the breast; when, roused by the continuance of the operation, he is incoherent, and touchingly speaks of something foreign to his actual state; when the drink offered to him is forcibly ejected from his irritable stomach; in these sad circumstances, we may say that the surgeon has been deceived, and that the

powers of life cannot sustain the injury, or that a chance of life is too dearly bought. The patient after the operation remains faint, and the pulse is not to be felt; he vomits; the stomach rejects drink; the pulse may rise, fluttering, to 160. He becomes restless, falls into a state of low delirium, is convulsed, and dies within twenty hours.

In noticing death from severity of suffering, whether from accident or in consequence of operation, we must mention another condition and very frequent instance of sudden death. An habitual drunkard has his thigh broken, or there is a bad compound fracture of the leg; he becomes delirious; the nature of his symptoms is misunderstood; to subdue the supposed inflammation, he is bled, and killed as by a shot.

To proceed with this fearful catalogue, we may look a little farther into the secondary and remote consequences of severe operations. The throbbing pulse, the hot and restless tossing of the succeeding night, may have been subdued; the secretions may be restored; antimonials and opiates may have been successful, and a hectic succeeded to the flush of inflammatory fever: but he has a dry cough,—a tightness of the chest; he breathes with a sense of oppression; these signs, in the circumstances, are alarming. The surgeon, regretting the loss of his patient,

remarks that, but for the accidental attack of inflammation in the lungs, his operation would have been successful. But this inflammation is not accidental; the vulgar expression is as correct as science can suggest. The vascular excitement falls on the weak part.* In a violent inflammatory fever, the lungs, or liver, or kidney, being in a state of incipient disease, will have the general action concentrated upon them.

Connected with this subject, there is one but darkly comprehended as yet: the inflammation of veins from the effects of wounds and of surgical operations. This follows on amputation, for example, and the symptoms are, frequent rigors and a low fever, with general sinking of the strength; with the pulse continuing at 130 or 140 in the minute. On death, abscesses are found in organs distinct from each other, and remote from the part in which the inflammation arose. Such collections of matter are not only found in the affected veins, but in the lungs and the liver, and remote joints; and these abscesses in the lungs and the liver are unlike those consequent on pneumonia or hepatitis; they are dispersed in different parts of the organs, are recent, and have no surrounding thickened walls.†

* The observation is in *Celsus*.

† This diverges into many other very important practical sub-

We now advance to a subject of the highest interest. During certain operations performed on the neck and shoulder, the patient has suddenly expired,—I may say, ceased to live. No word has escaped him, no sigh, nor convulsive motion. The operators, surprised at his quiescence, and regarding him, find that he is dead.

Critics have expressed their belief that these patients must have died of hæmorrhage; others that they must have died from the general shock to the nervous system. Dupuytren was accused of *amour propre*, his opponents alleging that he was desirous of accounting for his patients' death rather by some extraordinary and unlooked-for cause, than what might have been foreseen and guarded against. M. Roux, too, was criticised in the same manner by those, we may surely say, who could not have witnessed death from violence or from hæmorrhage; and the reader will now perceive why I have prefaced this subject by the statement of the more common occurrences succeeding operations, and causing rapid sinking of

jects; as those local affections produced by acute diseases. How many of the histories of our surgical cases commence with the acute diseases of youth. See *Dr Alison's Paper on Tubercles;* or *Sir James Clark on Consumption and Tuberculous Disease. Read also Mr Arnott's Paper, Med. Chir. Trans.* vol. xv.

the powers of life. Neither violence, nor loss of blood, nor even the bursting of the aorta, nor nervous influence, produce effects so sudden and appalling as this cessation of motion—as by a lightning stroke. That this catastrophe can be provided against, is another reason for entering on the inquiry.

On looking over my sketches of the wounded at Waterloo with the Baron Larrey, he fixed with interest on the case of a young man who had been wounded in the lower part of the neck. "Well I know," says this excellent surgeon, "how that man must have died. I have seen many so wounded during my campaigns, and die from air drawn into the veins."

The question was brought forward in 1822 by M. Dupuytren. He was operating on a tumour situated on the lateral and posterior part of the neck of a stout young woman. During the operation, and whilst an assistant raised the tumour, the operator heard a sound like the entrance of air into a void cavity: "If it were not that I am far from the air-tubes," said Dupuytren, "I should have supposed that we had opened them." The words were hardly spoken, when the girl said, "*Je suis morte:*" she trembled, and fell back without life!

In 1823, Delpech, having taken off the arm of a man of thirty years of age, found him thus suddenly dead. The arm was scarcely detached, when the man ceased to live, "*n'existoit plus.*" The thunderbolt could not have been more instantaneous in depriving the man of life.

In 1836, M. Roux, in removing the right arm of a man of fifty-three years of age, heard twice during the operation the noise of air drawn in. The operation was hardly completed, when he found that his patient had "ceased to live." The expression is particular, they do not see the man die, but find him dead.*

Dr Warren, professor of surgery in Harvard University, U. S., having wounded a branch of the vein joining the internal jugular, heard bubbles of air drawn in, and the patient fell insensible. (See his interesting volume on Tumours.)†

* "Mais elle n'était pas achevée, que mon malade avait cessé de vivre."

† In the same volume, p. 260, we have a vein opened in the axilla in extirpating a gland. "A vein was divided and a small quantity of venous blood discharged. Scarcely was this done, when the patient struggled, her complexion changed to a livid colour, and, at the same instant, a bubbling or gurgling noise, which had not been noticed before, was heard, though indistinctly ; but the place from which it issued was not visible, the surrounding skin and fat lying over it. On this, the axilla was immediately

It is unnecessary to multiply examples. Death has so occurred, and ought to have excited a livelier attention, for it is one of those subjects which, if followed up, will lead to matters if possible of greater interest.

How then is it that a man shall be thus cut off without a symptom, without a word uttered—without the distortion of a feature or the convulsion of a muscle, and this in such distressing circumstances as under the hands of a group of surgeons? It is ignorance to pooh! pooh! it down, and say that the patients die of hæmorrhage or of a shock to the nervous system, since we have seen that men do not die from these causes in that manner.

I can have no hesitation in joining my belief to that of others, who have accounted for such sudden

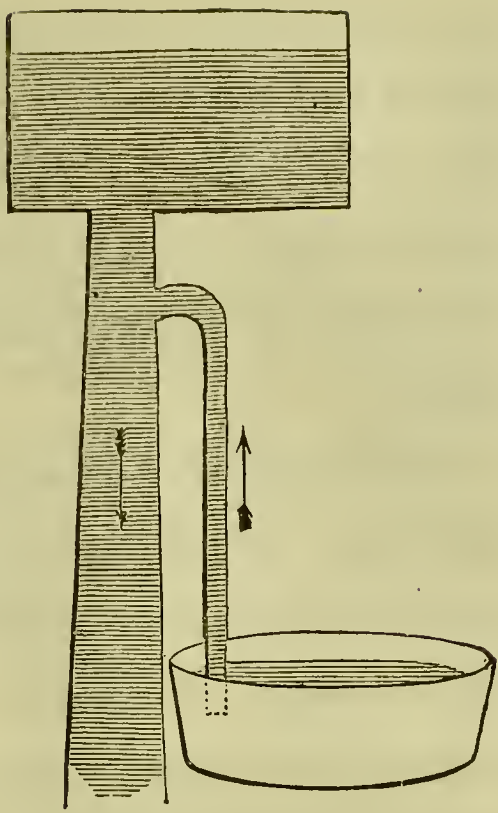
compressed. The patient became insensible, breathing as in apoplexy—— Some brandy was poured down her throat, and ammonia introduced into the nostril. The pulse, however, became less distinct every instant. Clothes dipped in hot water were thrown over the extremities. Strong frictions were applied to the chest," &c. This patient survived, but, from this narrative, I am convinced the patient was saved by the surgeon knowing the nature of the accident, and immediately compressing the axilla. Again, page 182, in operating on the neck, the jugular vein was divided. "A few bubbles of air entered the open mouth of the vessel, but were arrested by the finger below, and forced back again." The same occurred in the practice of Dr Stevens of New York.

death, by supposing that air has entered the veins of the neck; for strange as it may at first appear that any thing so bland as atmospheric air should instantly terminate life, yet we know that it has this effect. I have long ago, with many others, ascertained, that blowing air into the veins has this effect on animals; and it is not an uncommon manner of killing horses.*

Still the question arises,—when a vein is opened, does not the blood flow? How should the air in such cases be drawn in? I must be allowed to say that in this investigation, neither the hydraulic law, nor the action of the muscles of the neck, have been sufficiently adverted to.

In the first place, this is an established fact: when water flows through a tube, the tube being gradually larger at its further extremity, and a lesser tube be inserted into it, water will not flow from the larger tube into the smaller, but from the smaller into the larger. This corresponds with the course of the blood in the veins: for the lesser veins are inserted into a series of trunks gradually enlarging in their diameters, till they reach the heart.

* The professor of veterinary surgery, Mr Dick, tells me that it just requires three times the discharge of his lungs blown into the veins to kill a horse.



In these circumstances, a hole in the side of the tube will not discharge water, but will admit air. But it will be very properly objected, that the veins of the neck not being rigid tubes, the hydraulic law does not apply.

I am now to shew that these veins of the neck are subject to a condition still more favourable to the admission of air, than if they were rigid tubes.

The opinion which has most prevailed, as to the mode in which the air enters, may be thus stated. It is supposed that the right auricle of the heart, in dilating, has the effect of producing a vacuum, and of thus sucking the blood into it from the veins: it is further conceived that, when a vein is opened within a certain distance of the heart, so as to be affected by the supposed suction produced by the auricle of the heart, then, air will be drawn into it. But I think it most probable, that the commissioners, deputed to make experiments on this subject,* re-

* By the Academy of Medicine of Paris.

moved, in their experiments, the very apparatus on which the phenomena really depend. They *exposed* the veins; thereby destroying altogether the effect of the action of the muscles of the neck upon them, which is to expand these vessels, situated beneath them.

The coats of the veins of the neck are remarkably delicate. Accordingly, if a vein or a gut, or any such tube, membranous and soft, be attached to the nozzle of a syringe, we shall not be able to draw up water through the tube; because the sides are sucked in, or, in scientific phraseology, are subjected to the pressure of the atmosphere. This is too obvious to have escaped observation.

When this is granted, and when it is also allowed that the veins of the neck are precisely in this condition; that is to say, in communication with a cavity that exhausts them by suction; so that, whether the power in operation be in the heart or in the thorax, the suction cannot, on any supposition, be effectual; some mode of accounting for the veins not suffering collapse must be sought for.

It is by such considerations that we perceive, that there is an element wanting in the argument. *What, then, are the circumstances by which the veins of the neck can assume the characters of rigid tubes?*

In looking to a person breathing high or anxious-

ly, when the neck and breast are exposed, we see, without the aid of anatomy, that the sides of the neck, collar-bones, and shoulders, are raised at each inspiration; and that the effects on the veins of the neck are very remarkable. If the reader turns to the introductory part of this paper, in which the symptoms of hæmorrhage are enumerated, he will have a lively conception of what must be the effects of this rising of the shoulders during an operation attended with much loss of blood.

On examining the neck anatomically, we find the *platysma myoides* covering the side of the neck, and passing from the chest to the base of the jaw. This muscle lies over the external jugular vein, and the branches of veins which contribute to form it. The *sterno-cleido-mastoideus* takes its course obliquely upwards on the neck, to be inserted into the mastoid process. This muscle, with the anterior portion of the *trapezius*, and the clavicle, form a stratum lying over the internal jugular vein and the subclavian vein. This mass moves continually in breathing. The muscles, during inspiration, are lifted off the veins of the neck, and, by removing the atmospheric pressure from them, allow them to dilate. It is especially in high-breathing, that this influence of the muscles, in drawing blood into the veins, is powerful. On the subsiding of the action, during expira-

tion, the blood of the veins is propelled downwards in its course to the heart and the regurgitation is prevented.

But, perhaps, experiment may be necessary to illustrate the effects of the action here described.

Most of my experiments, I am happy to say, have been performed on the dead body. I made an incision on the neck of the subject near the clavicle; in the bottom of the wound I opened the vein, and filled the wound with milk; I then forcibly raised the shoulder, when the milk was absorbed into the vein. I requested Dr Reid to repeat this experiment, well aware of his ingenuity in such matters, and in his hands the success was perfect.*

* My dear Sir.—In accordance with your request I performed the following experiment.

In a subject, the thorax of which had been previously opened, an incision was made across the upper part of the lower third of the neck, through the integuments and *platysma myoides*, so as to expose the external jugular vein. An opening was then made into the vein, and by detaching the integuments in the neighbourhood of the vein, a small cavity was formed, capable of holding between one and two drachms of water.

This cavity was now filled with water, and the shoulder and clavicle were forcibly elevated, when the whole of the water entered this orifice of the vein.

To prove that the water did not enter from gravity, the cavity was again filled with water, and although a minute (and in subsequent experiments a longer time) was allowed to elapse, the

It must appear to the reader, that the state of the parts in death, and the raising the shoulder in this condition, is but an imperfect representation of what actually takes place in sobbing and sighing, or in the sudden alarm when one draws his breath convulsively. The experiment is, however, explicit as to the effect of raising this stratum of muscles and membranes off the veins which lie under them. Conceive, then, the condition of a person under operation, exhausted by the loss of blood, sighing and drawing breath as we see patients do in these circumstances. Conceive the veins opened, and the effect of a touch of the knife on a nerve—the sudden and repeated elevation of the shoulders and the chest; and we can have no difficulty in comprehending how the air enters the circulation.

water did not change its level; while, on the shoulder being raised, it rapidly disappeared through the orifice of the vein.

The same experiments were repeated, and with the same results.

It was distinctly noticed that, if the shoulder were very rapidly raised and again rapidly depressed several times, the water disappeared very slowly, and even sometimes appeared to remain nearly of the same quantity, though fluctuating; part of it being drawn into the vein during the elevation of the shoulder, and again forced back during its depression; while, on the other hand, if the shoulder when elevated remained in that position for a short time, the water entered and disappeared, and did not again reappear in the wound when the shoulder was allowed to fall back. I have the honour to be, your obedient servant,

(Signed) John Reid.

This subject has other interesting relations,* but we shall pursue our inquiry, *How is it that air admitted into the circulation causes sudden death?*

The researches of the French commission leave the subject obscure, for their many experiments are contradictory. It is at one time conceived that the animal submitted to experiment, dies in consequence of air admitted to the heart: or, again, to air passing into the minute vessels of the lungs; while others attribute the effect to the air being sent into the carotid artery and into the brain.

It has to be remembered that the mode of death which we have to explain is not such as we observe from a wound of the heart, for then death does not occur without symptoms, and more or less suffering. Nor is it death from congestion in the lungs that we have to explain; nor from the bursting of a vessel in the brain, where there is a period of stertor, and life is prolonged, though some volition be lost; but death on the instant, without a motion to give alarm, or to indicate the change which has taken place.† The heart, lungs, and brain, are undoubted-

* See the concluding note.

† I went into the dissecting-room of the Professor of Veterinary Surgery, Mr Dick: I found there a class of intelligent young men. They kill their horses and asses for dissection by blowing. Some said the animal would be convulsed, and struggle for a minute;

ly vital parts, yet all of them, when affected with disease, cause protracted suffering. What part is it which being injured will deprive an animal of life, as by a flash of lightning? It is by this course of inquiry that we are directed to some more vital spot. Some centre, which shall instantly and simultaneously influence the organs of breathing, of voice, and of expression. There is but one spot, which, being injured, shall have this effect—the *medulla oblongata*, giving origin to the nerves called Respiratory.

I readily concede that a blow on the stomach will kill instantly; that a blow on the breast, inflicted on the malefactor, is the *coup de grace.* I have said also, that a blow on the throat has been quickly fatal. In these instances, the influence still falls on that vital respiratory system, by which voice and expression are instantly lost, and death must follow quickly. It is recorded that, in experiments, a bubble of air will be sent from one cavity of the heart to another, and, nevertheless, it has not had an immediate deadly influence on the organ. The stomach may be removed from an animal, and that animal will continue to live. These facts indicate that when a

others, that he falls over at once motionless. It cannot surprise us that air in the heart and circulation of the lungs should be attended with distress; but that is not what is sought to be explained,—it is the sudden privation of life.

blow on the stomach kills, it is by an influence reflected back on the great nerve of the stomach to the centre of all these vital motions; and so I can believe that a *blow* on the heart may have a similar consequence, though a bayonet through the heart has no such instantaneous effect. It is rapidly mortal, but not without symptoms.

Again, experimenters record these extraordinary facts, that, when the brain is removed, the animal continues to breathe; that when the *par vagum*, that is, the nerve of the lungs, is cut, respiration continues; that after the *par vagum*, the sympathetic nerve, and the spinal marrow, are divided, breathing continues; that when the animal is exviscerated, the breath is still drawn!

Now, in contrast with all this, there is a point which, rudely touched, deprives the animal at once of every indication of life in sound or motion. In whatever manner injury may reach this part, it must be the source of death, in the instances we have stated. It may be an injury of the extremity of a nerve, given to the stomach or the heart, which propagates the fatal influence to this centre. But there is another mode in which its vital power may be suddenly cut off, namely, by air sent to the vessels of this vital part. We know the intimate, the immediate dependence which all organs, and especially those of

sense and motion, have on the circulation of arterial blood. Now, air passing into the vessels of that portion of the spinal marrow which is the source of all these vital motions, must kill instantly, like the crushing of the part itself.

In conclusion, we find from the Veterinary Professor that it requires three expirations from his lungs to kill a horse. We learn from the pupils that sometimes the horse or the ass struggles before death, but that he oftener dies by falling over at once without motion. The Professor informs us, too, that when, in bleeding a horse, "he hears the noise of air entering the vein, he claps his thumb upon it." We learn that the same thing has happened in operating on the neck and on the axilla, and that the patient has been saved by the same means. But we are most struck by the awful suddenness of the death in other circumstances, giving a powerful interest to the inquiry. I have on several occasions, when my brethren have been operating on the neck, slipt my hand in to press on the veins between the wound and the clavicle. When amputation is performed at the shoulder, the arm should be so held as to prevent the sudden rising of the clavicle, and if this cannot be done, let the mouths of the divided veins be compressed, until the final dressing and bandaging.

ADDITIONAL NOTE, No. I.

The natural course, to illustrate our subject experimentally, would be to blow air into the vertebral arteries, and observe the effects. But there is great difficulty in this. I applied to the veterinary pupils, requesting them, that, when they killed their animals for dissection, they would attempt to convey the air into the vertebral arteries; but in this attempt they failed.

In the mean time, I may refer the reader to a note in my paper on the Nerves of Respiration, &c. "I may here add a conjecture on the provision for securing the circulation through a part so vital as the *medulla oblongata.* The vertebral arteries are supposed to run in the canal of the cervical vertebræ, in order to secure the circulation in the brain, in the event of compression of the carotids; but, considering the command which this part of the medullary column exercises over the actions of respiration, and that it is more vital than the brain, may it not be a principal object of this very peculiar course of the vertebral arteries, to supply the organ of respiratory motion, free from the casualties which influence the supply of blood to parts of less consequence to life?" See Nervous System, 8vo, p. 110.

The interest of the subject is increased in no ordinary degree by the experiments of Sir Astley Cooper, who found life terminated without a struggle, in consequence of compressing the vertebral arteries.

ADDITIONAL NOTE, No. II.

In another part of these essays, I have had occasion to point to the peculiar condition of the circulation within the skull. In the action of the muscles of the neck, to which I have now been ad-

verting, we see another peculiar provision for the free descent of the blood from the brain, as well as for diminishing the tendency to regurgitate. When the veins of the neck are injected in the dead body, we see that the internal jugular vein is remarkably enlarged where it lies under the mastoid muscle; it forms here a great sinus. During respiration, especially high or excited respiration, this sinus is alternately subjected to the pressure and elevation of the incumbent parts; the blood is drawn into it by the elevation of the clavicle and mastoid, during inspiration; and pressed down in the course of the circulation towards the heart, by the subsidence of the incumbent parts during expiration. Without such an influence, there would have been an absolute stagnation of blood in the veins and in the brain, during fits of coughing, sneezing, and straining. But I have to shew that this action of elevation and depression of the muscles of the neck is undoubtedly the reason why the trunks of the absorbents enter into the venous system at this part.

It is correctly stated, that where two streams meet obliquely by the union of two tubes, there is a negative point at the part; there is no pressure of the fluid outwardly. Now, it is in such a part that the thoracic duct pours in its contribution, unopposed. But there are many such angles besides the union formed by the subclavian vein and jugular. As to the thoracic duct mounting on the neck, that the fluid from it may descend with force, it is a weak argument; for as long as the ascending part of the trunk is longer than the descending part, on the principle of the syphon, no additional force can be gained. I apprehend the reason on the contrary to be, the thoracic duct, by thus ascending under these active muscles of the neck, receives an impulse from them, both drawing and urging the chyle towards the veins.

If the subject were to be prosecuted, we might inquire what difference is to be observed in the course and termination of the trunk of the absorbents, when there is another form in the apparatus of respiration, than that which we find in man and quadrupeds. "In birds and reptiles," says Dr Alison, "there is a communica-

tion between the lymphatics and other veins than those of the neck." And in the batrachian animals, Professor Müller observes, that the trunk of the absorbents of the lower extremities, enters into the veins of the pelvis ; and a trunk of the absorbents of the upper part of the body joins the veins of the neck. But, in both these parts, there is this remarkable circumstance ; that a pulsating ventricle or bag is attached to the termination of the absorbing vessels, to assist in the propulsion of the chyle.

It thus appears, that, in mammalia, there is a rising and suction, through the action of the muscles of the neck, of which advantage is taken to aid the flow of the chyle. In the frog, the air is received into the pharynx, and propelled into the vesicular lungs ; and this change of the vital apparatus requires a different adjustment of the thoracic duct.

ESSAY II.

OF BLEEDING IN APOPLECTIC ATTACKS, AND THE DIFFERENT EFFECTS OF DRAWING BLOOD FROM THE ARTERY AND FROM THE VEIN.

Circumstances have occurred which have led me to resume the examination of this subject.

The volume and impetus of the blood transmitted to an organ being in proportion to the importance and the activity of the function of the organ, we perceive why there should be more blood sent to the brain than to any other part of equal size. When we consider, further, the extreme softness and delicacy of texture which distinguishes the brain, we see that it must be guarded from injury in a manner peculiar to itself.

The dangers which we have here to consider are from internal impulse; and though analogy may not be the best mode of reasoning, yet there is so much resemblance in the condition of the eye to that of the brain, both being subject to the same impulses

and concussions, that in contemplating the one we may learn to appreciate the provisions in the other.

The dangers to the eye, as well as to the brain, result from the impulse conveyed in a retrograde direction along the column of blood in the veins, which impulse, were it permitted to reach the extreme vessels, would be destructive of the web of nerve in the eye, or the structure of the brain. During passion, when the face is flushed and the veins turgid; during bodily exertion, when the respiration is stopped and the return of blood from the neck and head impeded; during a fit of coughing or sneezing, when the blood is driven, or regurgitates, towards the head, what protects the eye? what protects the brain?

The interior of the eye is protected during these jars—by the resistance of the strong sclerotica to distention—by the action of the muscles of the eyelids, which grasp and sustain the eye in consequence of their consenting in action with the muscles of respiration;* and, in an especial manner, by the forms

* If, while you yawn or sneeze, you put your finger on your eyelids, you will find, that, by the action of the orbicularis, in combination with the muscles within the orbit, they become as firm as a board. We see why the eyeball suffers in paralysis of the eyelids; for then this support is lost. If we hold up the eyelid of a child to look into the eye, while it is screaming, the conjunctiva is in an instant distended with blood, and for the same reason—the want of pressure and support to the surface.

of the veins themselves. Mr Alexander Shaw has given* a very ingenious explanation of the *vasa vorticosa* in the choroid coat, which by their form subdue the impulse along the veins of the head, that would otherwise reach the interior of the eye. The artery of the optic nerve and retina, it is likewise to be observed, is as tortuous as the internal carotid or the vertebral artery.

Thus, in the firmness of the sclerotic coat of the eye, the ready consent of the muscles to sustain the globe, the form of the *vasa vorticosa*, and the twisting of the arteries entering the eye, we see a provision against the impulse on the columns of blood, and the concussions to which its delicate parts are subject.

Now, looking to the condition of the brain as somewhat similarly situated—as subjected to injuries from without and impulses from within—we perceive how it is guarded against the latter. First, we perceive in the tortuous form of the arteries entering the brain, that it is preserved from the agitations of that system. Next we perceive that the veins are lodged in strong sinuses, formed by the dura mater, and strengthened by the chordæ Willisii, and which sinuses receive the impulses conveyed retrograde from the veins of the neck; the veins, likewise, which

* Medical Gazette, Oct. 1837,

join these sinuses, take a sweeping and curved course, by which the shock is diffused, before being carried onward to the minute branches; so that, becoming a general impulse on the mass of the brain, that organ is sustained by the uniform support and resistance of the skull. Take away a portion of the skull, and free the brain from this uniform support, and we have demonstration of its influence, by the protrusion of the brain and the bursting up of its vessels, during a fit of coughing, or during the violent efforts of intoxication or delirium. If in fracture of the skull the longitudinal sinus be also opened, the blood is poured out in a torrent during a fit of coughing.

Considering now the peculiar condition of the brain, and that there is no free space within the skull, certain consequences result: the fulness of the cranium, and therefore the equable support it affords to the whole mass, the tortuous form of the arteries entering the brain, the strong walls of the sinuses protecting the veins, cut off this important organ from all the irregularities to which the circulation of the trunk and limbs are subject, in the varying postures of the body, and in the impulses caused by the straining of the thorax and action of the limbs.

The head and neck may be surcharged and bloated with blood; while the brain will preserve its na-

tural condition as to the quantity of blood in its vessels.

If the arteries encounter a resistance to their dilatation by the contact and pressure of the brain, they must move that mass in dilating. Then the blood in the veins must partake of the motion thus communicated to the brain, and blood will be driven from the veins in proportion to what enters by the arteries. I thought of determining this fact by experiment, when circumstances occurred to render it unnecessary ; for, in a case of fracture of the skull, where a splinter had opened the longitudinal sinus, the blood came from the wound in pulsations, synchronous with the pulse at the wrist.

It would therefore appear, that, from the fulness of the brain-case, and contact of all contained, the action of the arteries of the brain gives an impulse to the veins ; and the veins cannot yield to that impulse in any other way, than by the discharge of blood in the direction of the circulation.

It must follow, that an impediment to the exit of blood from the sinuses, must prevent the free dilatation of the arteries. On the other hand, whatever facilitates the descent and flow of blood from the sinuses, must give freedom to the action of the arteries of the brain.

But further, when the skull is fractured and the

dura mater torn, we have another series of phenomena conducing to the right understanding of the condition of the brain and its vessels. On violent exertion, coughing and sneezing, the brain is forced out from the hole in the skull. The brain rises both by the impulse of the arteries and the shock carried retrograde by the veins. When, however, the patient dies, a remarkable change is apparent. The protruded brain has subsided within the skull and dura mater; and the surface of the brain has sunk away from contact with the dura mater.

From this it is manifest, that, in proportion to the mass of the brain protruded during life, there must be an accumulation of blood either in its veins or arteries, or an effusion of serum upon the surface, or in the cavities of the brain. Again, it must have been by the escape of blood from its vessels and the receding of this blood to the heart in the act of dying, that the brain fell off from the dura mater, and air was admitted into the brain-case between the brain and dura mater.*

By these considerations, or with these *præmissa*,

* Some of my friends speak of hypertrophy of the brain. Hypertrophy of the heart may be attended with excessive action. But increase of the mass of the brain, did it ever take place, must be attended with diminished circulation. Whence then should it arise?

we are prepared to comprehend the effects of extravasation of blood, upon the brain.

The studious reader will perhaps think that I have been too long of referring to Dr Monro [secundus], on this subject; who taught us the incompressibility of the brain: or to the very excellent commentary by Dr Kelly. The latter made ingenious use of the elements taught by our common preceptor. My late esteemed friend, Professor Coleman, found no plethora in the vessels of the brain, of animals which had been hung. Dr Saunders and Dr Seed [thesis 1815] found that the veins of the brain were not depleted by bleeding; and Dr Kelly made many ingenious experiments to the same effect, shewing that, if the vessels of the brain were in any degree emptied, serum must in the same measure be effused. All these experiments are to shew "the difficulty of repleting or of depleting the vascular system of the brain."

The principle, however, wanting in these inquiries, is the very essential one—that all qualities of *life* are maintained through the active circulation of arterial blood in the substance of the organ. The stagnation is equally fatal with the entire want of blood. Yet, not denying the beneficial effects of bleeding in apoplexies, authors linger on the hypothesis of Cullen, that drawing blood takes off the pressure of the vessels of the brain upon its substance, and so affects "the mobility of the nervous power."

Pressure on the brain ought not to enter into the inquiry. If the brain be inflamed, we bleed to diminish the velocity of the circulation—the freedom with which the blood passes from one set of vessels into the other—because it is this active transmission of blood from artery into vein by which the inflammation is maintained. If we suppose that a vessel is ruptured in the brain, we bleed to diminish the force of the circulation; because we know that the mouth of a torn vessel will close by the coagulation of the blood when the stream is diminished in force: it is the same principle which makes us bleed in a deep wound with hæmorrhage in the lungs or in the abdomen.

But, as the circulation within the skull is peculiar, a question arises, in what vessel, in vein or artery, ought we to bleed? a question, as I take it, of vital importance.

Let it be supposed that an artery of the base of the brain, by disease of the coats, or by violent impulse, gives way. The blood thrown out, is diffused around the brain, until checked by the general resistance. In proportion as the blood escapes from the torn vessel, the vessels generally must be compressed,—there must be a resistance to their dilatation; and, consequently, their action must be diminished, for there is neither free space nor compressible substance within the skull. Whatever energy

of function depends on the freedom of circulation in the brain, must be diminished, or altogether lost.

When the smaller arteries of the brain, in consequence of previous softening of the brain, or independently of that cause, are ruptured and give out their blood, as often happens in the *corpus striatum*, the general effect is less, the partial injury greater; the clot presses aside, or ruptures the fibres or the tracts of the brain on which sense and motion depend. But the extravasation may exceed its first bounds, the blood may burst out and deluge the surfaces, or fill the ventricles, producing apoplexy, supervening on partial paralysis.

How is this outbreak, which is comparatively trivial at the first, to be limited? What means have we of diminishing the arterial impulse, without taking off the general pressure which tends to resist the further extension of the clot? Bleeding, it has been said, cannot diminish the quantity of blood in the brain. This is true; but it can retard its velocity, and alter the relative proportion of it in the veins and in the arteries. It can prevent that blood from forming a mass of coagulum, instead of being retained in its natural state within the vessels.

Let us endeavour to make a familiar illustration. Suppose we take a glass-jar from the trough of the chemist, fill it with water, close it, and through the

cork or luting introduce two glass-tubes also full of water. In this state invert it. If the tubes be of equal length, no water will flow; but if one be longer than the other, the water will pour from it, whilst air ascends by the other tube. But if, instead of admitting air, the shorter tube has its mouth in water, that water will be drawn up, and, if coloured, it will be seen to be received and diffused among the water in the jar. The reader cannot mistake which tube represents the vein and which the artery; nor will he fail to perceive that, if facility be given to the descent through the long tube, the coloured fluid will diffuse itself more freely by the shorter tube.

After the preceding statement, is it proper, in the case of extravasation of blood in the brain, to open the temporal artery, or to draw blood from the venous system? It is evident to demonstration, from the external arteries of the head and the internal arteries of the brain being branches of the same trunk, that the opening of the external branch must, on all principles, vital or hydraulic, diminish the flow of blood through the internal. If, while looking on a jet d'eau, we see the column of water suddenly drop, we may be assured that some one is drawing water from a branch of the same conduit pipe.

If blood be drawn from the veins, and more especially from the veins of the neck, facility is given to

the descent of blood from the sinuses, and the pressure on the brain is diminished, by which the tendency to the extension of the clot and to the additional flow of blood from the burst artery is increased.

It has been to me a matter of observation, and has indeed led me into this disquisition, that a patient being sensible of a seizure, and feeling his arm and leg numb, has had the temporal artery opened; and as long as the blood drawn jetted with force, he has continued to be relieved. Afterwards, being copiously bled from the arm, I have found him completely paralyzed on one side. Now, this increase of the evil may have been the uncontrollable progress of the disease; but, as the same thing has occurred more than once, it gives rise to serious considerations.

Apoplexy is an extensive subject; and our respect to ancient authorities places it in great obscurity.*

* Apoplexy is characterized by the semblance of profound sleep, with stertorous respiration. Sense and volition are gone, while the respiration and the action of the heart remain. Syncope is distinguished by the influence commencing in the heart. In apoplexy the heart beats after the last drawn breath.

Some authors contend for stertor being invariably an accompaniment; others find apoplexy without stertor. *Stertor* is produced by the breath playing through the relaxed velum, and may be avoided by attending to the position. By turning the body a very little, the velum falls forward, and the breath is drawn softly. The

But I limit myself to the case of clot from ruptured vessels in the brain. In such a case, apoplexy and palsy are allied,—a rupture of a vessel in the brain may partially break up the texture of a portion. Is it not the tearing up of the brain, as distinguished from the general extravasation, that occasions the contraction of the pupils in some cases? and is it not this tearing of the fibres which produces partial debility in the frame, or a numbness and inability to move in the opposite limb? But the blood, as in external hæmorrhage, may burst out again, become diffused on the surfaces, cause general pressure, and so apoplexy will succeed to palsy. Or it may happen that the first burst shall be sufficient to deprive the patient of all sense, and yet the clot may so contract and waste that, from the apoplectic state, the patient survives; and there remains more or less impediment to the motion or sensation of the part of the frame to which the injured fibres of the brain refer.

Certainly cases do not always occur in this simple form. Let us present to ourselves a case where we

agony of a family around a dying person may be much mitigated by so simple an expedient; yet great authorities measure the strength of the disease by the degree of stertor; or, again, they say that *snoring* is pathognomic of apoplexy. It is correct of laborious breathing: the more the respiration is affected, the more imminent the danger.

see the cause, progress, and termination. A fellow has drunk himself into a state of apoplectic stupor; from similar states he has often recovered; but now he dies, and a clot is found in his brain. Here we have the dangerous state of arterial excitement artificially produced. But there is a similar condition of the brain and its vessels, where, instead of intoxication, a spontaneous and morbid excitement prevails, attended with a dangerous activity of circulation. There is redness of the eyes, turgidity of the features, vertigo and drowsiness, and ringing of the ears, and torpor of the hands, and every symptom of "fulness of blood" in the vessels of the head. Bleeding and antimonials may subdue this paroxysm; but after a time it returns without apparent cause, and the blood is driven impetuously to the head. This is not a disease of the vascular system, but of the brain; a condition of the organ which draws after it the excitement of the vessels. And of all the feats of skill which the physician has to perform, the correction of this disposition is the most difficult and the most meritorious. The mere reduction of the force of circulation by the use of the lancet leaves the cause prevailing, and the danger recurs.*

* A communication has been made to me, which touches this subject. "Your old patient Leslie, from whom you took a large

There are other circumstances to be briefly noticed, lest I be thought to teach that drawing of blood is the sole or chief order of practice, in what are termed "head cases." When I have examined the head of a man who has died of apoplexy, and found a clot of blood extending from the *corpus striatum* into the ventricles, it has appeared to the bystanders quite satisfactory, the cause of death being apparent. But when we try back, and compare symptoms, we find that the friends interested in the patient have not only observed him declining in

portion of the skull, has had fever, followed by erysipelas of the head; it was frightful to see the quick hammering of the dura mater, more forcible than the pulse at the wrist."

This reminds us that the brain may, in these circumstances, be in danger from general vascular excitement, as well as by that excited through the brain. It may further give us reason to wonder that the brain can sustain such evident disturbance, unless we suppose that something similar always prevails.

In stating briefly, as in the text, that condition of over-action in the vessels of the head, which is the consequence of brain affections, I ought, perhaps, to remind the reader that similar symptoms arise from a less dangerous influence; that we see it in disturbance of stomach, in uterine derangement, and in fever, &c. There is an advice descending to us from our elder physicians, *e. g. Hoffman*, vol. i. p. 344, *Centur.* ii. and iii., *Sectio* iii., *Cos.* xiv., and others, to regard the effects of suppressed hæmorrhoidal bleeding. I see reason to regard that caution; and to advise bleeding from the hæmorrhoidal vessels, rather than from near the head, when periodically requisite; the physiological reasoning is obvious.

health, but a degree of dragging in the leg, long previous to the final attack which has suddenly proved fatal. There must, then, have existed some cause of numbness and weakness previously, and independent of the violent tearing up of the brain, and general pressure from extravasated blood. It is in such cases that, instead of finding a large artery ruptured, there is a series of lesser vessels, the mouths of which cannot be discovered, which have given out their blood; so that we are directed to a state of the brain antecedent to the rupture,—a partial diseased state attended with softening, and into which the blood has been poured.*

There is yet another cause of apoplectic symptoms which it is well to notice, especially with a view to the use of the lancet. The veins of the neck being pressed upon, as by violently turning the head, by inverted position, or partial strangulation, apoplexy is induced. Here it is not an accumulation of blood in the brain, but an interruption and stagnation, which, equally with the rupture of a vessel, influences the brain and diminishes the nervous energies. On the

* I must admit that there is extensive softening of the substance of the brain, without extravasation of blood. However we may look upon it, it is the premonitory symptoms that are most obscure in this interesting inquiry: the *precursors*, the headach, ringing in the ears, vertigo, hesitation of speech, and torpor of the hands, are not explained by a clot of blood in the brain.

examination of the brain in such cases, the veins of the brain are turgid to an unnatural degree, accompanied with a corresponding compression of the arterial system. Here the effect is not much different from the strangulation of any other part. The blood is accumulated in the veins, and the circulation arrested, and the activity of the arteries diminished proportionally. Thus, death is not the effect of pressure on the brain by the distended veins, but the oppression of the free arterial action. I must again refer to the fact, that it is not the quantity of blood within the vessels of the brain which sustains the functions, but the free passing of the arterial blood from the smaller arteries into the veins; we see therefore how sense and motion are diminished, and at length life extinguished, without rupture of a vessel.

If this condition of the circulation could be with precision ascertained, bleeding from the vein would be preferable to opening the temporal artery.

One more example in explanation of the state of the circulation in these cases. An elderly person, stooping, as in tying his shoe-string, having risen, falls and becomes apoplectic. In the first place, the compression of the chest and the difficult descent of the blood through the veins of the neck retard, or, to a certain degree, impede, the free entrance of blood by the arteries of the brain. But on suddenly rising to

the erect posture, there is a more dangerous period; for then the blood has more than freedom of descent from the head; the lengthened column drawing down the blood from the state of remora, it rushes into the brain through the artery, attended with pain and giddiness; and then it is, if I have not deceived myself, that owing to the pressure, which is the security of the vessels of the brain, being suddenly taken off, the artery gives way.

We have, hence, in such an occurrence, two distinct causes of *defaillance*,—the interruption to the free exit of the venous blood, and consequent impediment to the dilatation and action of the arteries, which of itself will cause apoplexy. Again, we have the rapid descent of the blood from the sinuses into the veins of the body, and the pressure taken off from the brain, giving rise to rupture of an artery. But the rapid re-entrance of blood into the brain produces very unpleasant effects, without rupture.

Take, in illustration, the pressure on a nerve. When we sit too long pressing on the ischiatic nerve, the circulation is impeded in it; when we rise, the circulation returns forcibly; and if the limb be then used, it is weak, numb, and painful; as we say, "it is asleep." Here the sudden return or readmission of the blood into the nerve has more dis-

tressing effects than the partial deprivation of blood which the nerve had sustained. The same effects result from the temporary application of the tourniquet to the limb.* Is the analogy a fair one,—that, after being long in the stooping posture and suddenly rising, and the blood having unusually free admission to the brain, giddiness and inability to command the limbs are the consequences?

If we look to the paper by Dr Fothergill† on the practice of Bleeding in Apoplexies, we perceive a struggle in his mind between the prevailing precepts of the profession and the experience of the acute and learned physician. It is a subject, he says, "which requires the most dispassionate consideration." He gives a case which made an impression on me, when I heard it from the mouth of Dr Gregory, in his lectures. It is known to every one, because the same circumstances are recurring from time to time, to renew the recollection. It is that of a gentleman passing the Thames in a wherry, and looking round at his brother's vessel, "he kept his eye on her after she had gone by, till he lost himself and sank down in the boat." Here we have obstruction to the exit

* The return of sensibility, after suspended animation from drowning, is attended with painful irritation.

† In an appendix to his paper on the Cure of Epilepsy,—his Collected Works, vol. iii.

of blood from the head, and consequently obstruction to the entrance of it. If our premises have been just, there can be no turgescence,—no more blood in the brain than is necessary to it. But there is a remora, an interruption to the free course of the circulation, and a loss of that support of the vital operation which is bestowed through the circulation.

In conclusion, if the lancet is used, under the impression that there is extravasation of blood, and the fear that the clot may become more extensive, the most efficacious mode is to open the artery.* If remora and obstruction to the exit of blood from the head be suspected, then phlebotomy is proper; still, in that case, arteriotomy is not improper.

* Draw the shoulders of your lancet across the anterior temporal artery so that you partially divide it; and judge of the quantity of blood to be drawn, by the force of pulsation and the distance to which the stream is sent.

ESSAY III.

ON SQUINTING—ITS CAUSES—THE ACTUAL CONDITION OF THE EYE—AND THE ATTEMPTS TO REMEDY THE DEFECTS.

It is pleasant to turn from the contemplation of the effects of violence, and the more severe operations of surgery, to a delicate operation which remedies a defect (which at least gives great uneasiness), and is really a triumph of art. But, while it is agreeable to witness the rapidity with which information is received and acted upon, and the eagerness of surgeons to put in practice a new operation, it is to be regretted that the physiological principles relating to the cure of this deformity have not been more attentively studied.

Vision is a subject of high interest in a physiological point of view. It has been studied by our philosophers in every age, and now a correct knowledge of the functions of the eye becomes more especially of practical importance, by enabling us to judge of the propriety of operations for the cure of squinting.

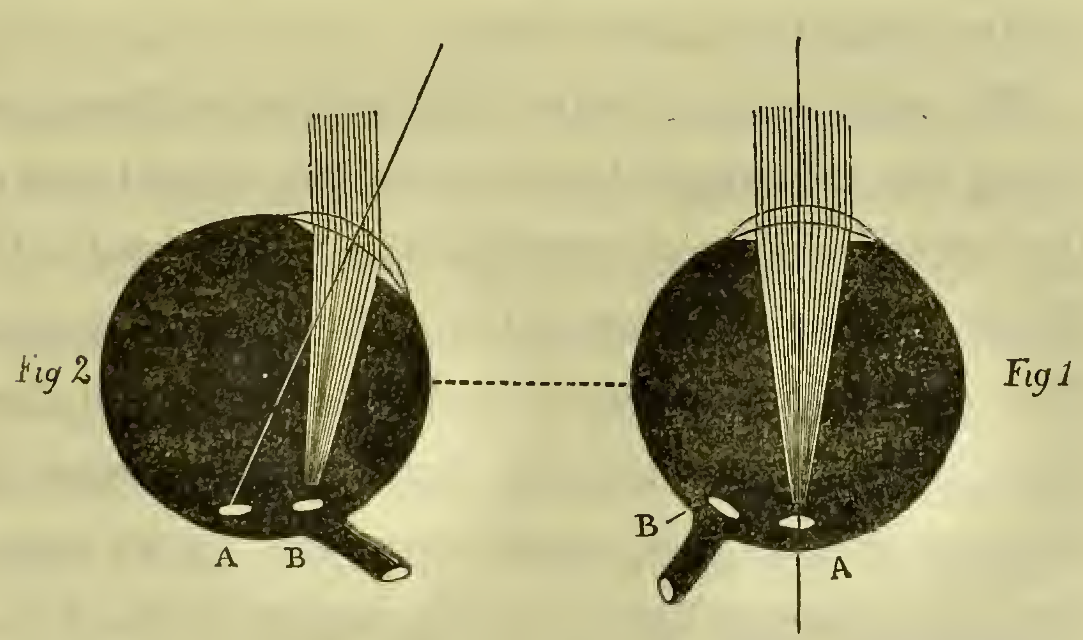
I have to confess that when, formerly, I endeavoured to shew the strict relation which exists between the action of the muscles of the eye and the impressions on the retina, I met with criticism from one, whose authority carries great weight in these inquiries. But my respect for that gentleman does not overcome the conviction that, on this question, and on all that regards the exercise of the eye, we must hold in view two distinct properties of the organ,—the reception of light on the retina, and the consentaneous action of the muscles of the ball of the eye. This relation becomes a matter of the first consequence in endeavouring to comprehend the subject of squinting, and to enable us to judge of the propriety of the operation for remedying the defect.

There are in the retina two spots distinct in their properties from the general surface. Though not antipodes in place, these spots are opposed to each other in respect to sensibility, one being exquisitely sensible to the impression of light, and the other absolutely insensible. The sensible point is in the axis of the eye, and is the foramen of Sœmmering; the insensible spot corresponds to the insertion of the optic nerve.* When the rays from an object im-

* See Mariotti, and the Experiments of De la Fond, Cours experimental, t. III. § MDCCCXCVII. Haller, Picturæ locus, lib. XVI. t. V.

pinge on the sensible part, animation and effort are immediately given to the guiding muscles of the eye. When the rays fall on a part of the retina removed from this centre of sensibility, and more so when they strike on the absolutely insensible spot, the stimulus to a correct action of the muscles is lost. We shall presently find that the defect of the weak eye of one who squints, is mainly in the tonicity of one muscle, and that it is at this time of comparative inaction that the other muscles prevail against it.

Take the plan, fig. 1, as representing the right eye, and the small circle A as the sensible spot; the rays from the object falling upon A are seen, and



animate the organ. Suppose fig. 2 to represent the left eye distorted to the degree that the rays fall on B, that being the insensible spot, the object is not perceived with that eye.

The farther from the sensible spot in the axis of

the eye the rays from the object fall, the less distinct is the image. Thus, in the common experiment by which an object is seen double, that is, of looking on another object beyond it, so that the rays are made to fall on the inside of the central and sensible spot of the retina, these double impressions are weak, compared with the single image. Accordingly, it is not required that the rays should fall on B alone, to be neglected. If the point on which they do fall be considerably removed from the spot A, the muscles of the eye will be without their sufficient stimulus to correct vision; and, being left uncontrolled, the weak muscle will yield to the prevailing tonicity of the others.

We ought not to leave this subject without noticing the advantage derived from the central spot of the retina being more sensible than the general field. Were the whole surface of the retina equally susceptible of the impressions of light, we should be dazzled, and see nothing; the direct light, whether of the sun or of a lamp, would overcome, by its intensity, the reflected light from the object to which the eyes were directed. That rapid search which the eye makes in surveying a scene,—the desire to have the object which is faintly seen on the general field of the retina presented to the sensible centre, as well as the happy consequences of that perfect vision which

results from the sensation on the retina, being combined with the voluntary direction of the eye, would all be lost.

Leaving this department, let us give more attention to the muscles of the eye. And I shall be excused in stating here what I have already taught on this subject.* The eyeball is suspended in a cellular and adipose membrane so loosely, that it is like a thing floating in water, ready to move on the slightest impulse. It is surrounded with muscles; the four recti embracing it, and terminating forwards; the two obliqui embracing it, and terminating backwards; while it is covered anteriorly by the orbicularis of the eyelids. We contemplate these muscles in two conditions,—a passive and tonic state, during which the eyeball is poised between them; and the more animated and active state, when the axes of both eyes are directed to an object. When the muscles are left in their passive state, their unexcited condition, the eyelid is dropped, and the pupil a little turned up; this is the state in sleep.

But of these muscles a certain class is voluntary. At the moment of awakening, the atollens palpebræ lifts the eyelid, and the recti muscles direct the axis of the eyeball to an object, or search for it; and that

* Nervous System.

search is to place the centre of the retina in such a relation to the object as that the reflected rays from it shall fall on the sensible spot, and then the object becomes distinctly visible. Vision thus obtained is the conjoint operation of the voluntary muscles of the eye and of the impression on the retina; and this double operation is necessary to perfect vision. It is that state of speculation which implies scrutiny; the motion, and sense of the eye being combined; and the correspondence in motion and in sensation of both eyes being perfect.

When a child has never seen, as in the case of congenital cataract, when there may be sensibility to light, without an image *seen*, "the eyes roll in different directions, and without correspondence."*

But certain of the muscles of the eye have another all-important office, without the performance of which we should not long enjoy sight,—the protection of the organ. For this the exquisite and peculiar sensibility of the surfaces of the eye, and of the roots of the cilia, is bestowed; and under this sensibility the action of the muscles is arranged. For example, in couching, the surgeon entreats the patient to command himself, and to look straight forwards, which he does; but the instant that the eyeball is touched

* See the cases, No. CVI. of Nervous System.

with the point, it is *involuntarily* turned inwards and upwards. What is the object of this in nature, and how accomplished? Is not this the position of the eye of one who has a decided squint? May not the investigation of the one condition tend to the understanding of the other?

How directly the cornea is turned towards the inner canthus, may be determined by a simple and harmless experiment. If, on closing the eye, and placing the point of the finger on the eyelid so as to feel the convexity of the cornea through the eyelid, we make an effort more firmly, and, as it were, spasmodically, to shut the eyelids, as if something were entering the eye,—it will be found that the cornea slips from under the finger, towards the inner canthus. On ceasing to exert the eyelids, the cornea returns again under the point of the finger to the centre.

The apparatus for throwing out what is offensive to the eye is not so perfect in man as in quadrupeds; but the mechanism is in some degree the same. The caruncle with its glands, and the membrana semilunaris, are less perfect than the haw, and the muscles of the human eye are deficient in the retractor muscle; but the action of those which we possess is the same, when there is irritation of the surfaces. The eye is dragged towards the os planum, the cor-

nea is turned to the caruncle, and the fold of the conjunctiva, called semilunaris, is thereby thrust forwards. By this means the dust which is floated towards the inner angle of the eyelids, is extruded.

It is obvious that this motion implies the combined action of all the muscles of the eye and eyelids, with the exception of one, most material to our subject,—that is, the external rectus. Without the relaxation of this muscle, the cornea could not be turned into the inner canthus; and without the alternate motion of the cornea to and fro, by the successive contraction and relaxation of the external rectus, the eye could not by any action free itself of the offending body. We come to the conclusion, then, that the external rectus has something to distinguish it from the other muscles; and so far we are on our way to comprehend its peculiar defects. We perceive that, in an obstinate squint, the eyeball is exactly in the position into which it is thrown in the sudden action of guarding the eye!

We may observe here, that the operation of cutting across the rectus internus muscle for the cure of a squint, was not undertaken on a deep consideration of the condition of the rectus externus; but it was to cut across what appears to the patient's feelings to tie the eyeball, and confine it towards the nose. Sometimes the patient, when you examine the eye,

and desire him to turn the eye outwards, says he cannot do so beyond a certain degree; and he will add, that it seems tied. But this is not a common attendant on squint.

Neither is there a doubt but that the internal rectus, by its continued action, acquires strength; while its antagonist, the external rectus, by the reversed condition of relaxation, becomes weak. The opposite effects which have followed the operation of cutting the muscles, and the disappointments, after much experience, call for a more philosophical investigation of the subject.

Every person understands, that to act, requires a stimulus to the contracting muscles. But it is only a physiologist who can comprehend that in every such action, there must also be relaxation of the opposite set of muscles. And I have elsewhere* said, that this is not a relaxation like the throwing loose of a rope. The relaxation of a muscle is as fine, or rather a more delicate administration of power than the contraction. It is the derangement of this relaxing influence which produces squinting.

Many of the actions or motions which, in a morbid condition, or resulting from accident, appear irregular, and cannot be accounted for, may be ex-

* The Hand, a Bridgewater Treatise.

plained by a careful study of the natural functions. Thus, in No. CIII. of the cases in the Appendix to my volume on the Nervous System, we find this passage,—" There lies in the hospital a patient with a fracture of the base of the skull, in whom there is a regular motion of the eyeball, as regular as the motion of a pendulum, from right to left." In case CV., the same motion is noticed,—" It is not so much upwards and downwards, as in a transverse direction." This is a derangement in the condition of the rectus externus, imitative of its natural function.

I must now advert to some of my experiments* on these muscles: a more objectionable mode of inquiry, perhaps, from its cruelty; yet I thought I was making it unnecessary for others to have recourse to the same. Experiments must be made on the monkey; the only animal that has the same muscles as man. The possession of the powerful *retractor oculi* will render all experiments on quadrupeds unsatisfactory.

I divided the rectus superior; the animal lost the power of raising the eye, when he raised the eyelids, and turned up the other eye. The eyelid was held open, and the eye touched with a feather; the cornea was instantly turned up, and in a greater degree than in voluntary action.

* See Nervous System.

This was surely sufficient proof to shew that the recti and obliqui were distinct in office,—that there were two distinct muscles employed in raising the eye; the one, the rectus superior, directing the eye in vision, and voluntary; and the other, the inferior oblique, acting involuntarily, for the protection of the eye, and for wiping the cornea, and dipping it in the fountain of the tears. Those who could not assent to the argument, that the oblique muscles perform their motions more rapidly than the straight, and, therefore, that these different classes could not correspond in any combined actions; or who could not see that, if there was a necessity for oblique muscles to direct the eyeball, there should have been four muscles and not two, might still have given their belief to so decided a proof of difference between them as this experiment afforded.

I cut the superior oblique muscle of the monkey. He was very little disturbed by the experiment, and turned his eyes in all directions, with his characteristic inquiring looks. On holding open the eyelid, and waving the hand before him, as threatening the eye, the eye turned up further than the other eye; and there was a hesitation and apparent difficulty in bringing it down again.

The division of the inferior oblique muscle did

not in any sensible degree impede the voluntary motions of the eye.

If any one will give a moment's consideration to the subject, he will see that the eyeball must be rolled upwards by different muscles. When we look upwards, the eyelid, as well as the cornea, is elevated; and there must be a perfect accordance in the action of the superior rectus and of the attollens palpebræ, or the pupil will be hid under the eyelid. But as the cornea is raised in the other action, for preserving the eye, while the eyelid is depressed, it must be effected by another muscle, namely, the inferior oblique, which consents in action with the orbicularis oculi. The one muscle accords with the elevation of the eyelid, the other with its depression.*

It would appear that our operators sometimes think physiology a matter foreign to their pursuits. Yet, in this subject, we cannot comprehend the most common occurrence without a knowledge of function. There is a squint, for example, that puzzles not a

* If the intelligent reader will peruse the cases of involuntary motions of the eyes, consistently with perfect and steady vision, he will have additional reason to conclude that vision is a double operation, combined, of the impression on the retina, with the sensible operation of the muscles of volition. See Nervous System, p. 374. ¶ *Nystagmus bulbi.*

little, and obscures the reasoning in common cases of true *strabismus.* The cornea is directed upwards, attended with adhesion to the eyelid. This is one of the effects of the action of the inferior oblique, in turning up the eye during irritation. In inflammation, the irritation being excessive, the cornea is turned up, and often it is permanently fixed by adhesion in that position. In such distortion of the eye, the interior has probably suffered; often the eyeball is small and sunk.*

Out of these experiments, there arises a question;—When one of the recti muscles is divided, the pupil is directly and permanently drawn in the contrary

* We ought to have a term for this permanent distortion, and *Luscitas* is by some applied. But authors use it in different senses. " *Strabismus* est, quando uterque oculos ad exteriora conversus est, *Luscities* quando introrsum ad nares."—*Boerhaave.* The conclusion of the paragraph I like better, " Omnes hi morbi nunquam intelliguntur nisi cognitis conditionibus, quæ ad visum requiruntur." The unequal action of the muscles moving the eye is *Strabismus.* The unstable and frequent motion of the eye, *Hippos,* by Galen. See Histoire de Chirurgie, De Gorter, &c.

The eye may be tied by adhesion, so as to be drawn from the true parallel, and so produce double vision. The adhesion may be stretched, or the eyelid may be so relaxed, as to admit the ball to resume its place. See *Langius* as quoted by Porterfield, Ed. Med. Essays, vol. iii. p. 159. Such adhesions, when the interior of the eye is sound, admit of operation.

direction: why does not the same follow the division of the internal rectus, in those that squint? We know nothing until this be explained.

DOUBLE VISION—THE STATE OF THE EYE IN INTOXICATION.

In soporific affections, the brain influences the muscles unequally. In intoxication, we have demonstration of what we may also perceive in the end of fever, and in acute hydrocephalus. By our best physiologists, the position stands thus,—When the brain is oppressed, the muscles which are most directly under the will are the soonest affected, and to the greatest degree. The progress of the drunkard, from the first stage, when he attempts, in vain, to snuff the candle, to his finally falling under the table, gives proof of the gradual manner in which debility encroaches on the muscular system. First of all, his sight is affected, and he sees double;* because the recti muscles, those of direct volition, soonest yield to the influence, and the obliqui, the involuntary

* It is classical. Pentheus driven to fury by the Bacchanals, is made to see double; two suns. Virgil Æneidos, iv. 469; Eurip. Bacchæ, 918; and Juvenal, sat. 6.—jam vertigine tectum

Ambulat, et geminis exurgit mensa lucernis.—

muscles, prevail, so as to disturb the adjustment of the eyes.

Double vision, then, is the deranged condition of the muscles of the eyes, by which the rays from an object are made to fall on points of the retina which do not correspond; and two weaker images, instead of one stronger, are presented to the mind.* Still this distortion of the eye is not a squint, nor does it depend on the same cause.

I have known a person who squinted, to be sensible of two images, one distinct, and the other very feeble. But, in general, he who squints sees single. The difference is manifest between double vision

* In hemicrania and sympathetic pains of the head, the eyes suffer. Dexter oculus visu tantum non omni privatus si cum sinistro simul ad videndum aperitur omnia objecta sistit duplicata: hinc aliquid lecturus, scripturus aut exacte consideraturus, dextro clauso solo sinistro uti valet oculo, &c. *Hoffman*, *Cent* i. *Sectio* i. *Cas.* iii. Double vision coming on in the adult, we fear that gutta serena may follow. Disput. Inaugural. Halleri, De Visu duplicato. Obs. iv.; Ratione *eventus* in visum duplicatum *curabilem*, Obs. 1, 2, 5, 6; *incurabilem*, Obs. 4, 11; *lethalem*, Obs. 7; see also Briggs. With double vision we have Vertigo. It disappears when the patient shuts one eye and sees single, if it proceeds from derangement of the action of the muscle. A person with double vision from slight cerebral affection cannot see, he is afraid of losing his way. But on closing one eye, he sees perfectly. Here, when both eyes are used, the impressions are not made on the centre of either eye, and hence weakness and confusion of sight. See cases by Dr Mackenzie of Glasgow, p. 302.

and squinting. In the former, both eyes are distorted, and on both the image is faint, because the rays from the object do not fall on the central points, —the sensible spots of the retinæ. In the latter, that is, in squinting, the defect is in one eye. It is distorted, and the rays fall on the less sensible part of the retina; whilst the sound or unaffected eye has the rays falling on the sensible spot, and the sensation is distinct. By and by, the stronger image is alone contemplated, to the exclusion of the weaker, and single vision is the consequence.*

A SQUINT—HOW PRODUCED—THE CONDITION OF THE EYE.

A person who squints has one eye distorted; notwithstanding which, he sees single, and is not sensible of any defect. If the stronger eye be shut, he readily turns the weaker to the object. Nor must it be forgotten that, when looking with both eyes, the weak eye accompanies the strong in every motion, but always preserving the same relation,—the axis of the weak eye deviating in a certain constant

* I beg the reader to peruse the case CXII. of the Nervous System, and to reason upon it.

degree from that of the stronger one. These facts do away with the idea that there is any one of the recti muscles incapable of action; or that the cause of squinting is any thing more than a certain degree of imperfection of the muscular power.

The following is a frequent occurrence, and it shews how liable the external rectus is to derangement, and the effect of weakness in it. An elderly lady complains that she sees double. It appears that this is only when she directs her eyes to the left side. I place myself before her, and she sees me correctly and distinctly. I move to the right side, and she still sees me single. But when her head is kept steady, and I move to her left side, and direct her to follow me with her eyes, she sees me double, —she sees two figures, one-half of the one figure over the other. I move a little farther to the left, and the images separate. Still as I move farther to the left the images are more separate, and one is faint compared with the other.*

We see here in an elderly person the progress of that defect in the rectus externus, which leads to squinting. When the external rectus of the left eye is relaxed, the imperfection is not perceptible.

* See a case precisely similar, in my Nervous System, No. CXVIII. See also the case in the succeeding pages 389 and 390.

The muscle is defective only inasmuch as it cannot fully contract, and therefore the eye cannot be directed outward to the degree that the other eye is directed inwards. The consequence is, that the impressions on the two retinæ no longer correspond,* and the more the right eye is turned toward the left, the farther are the impressions on the retinæ apart, and the farther the images seem to separate.

With this state of the ball of the eye, the upper eyelid is sometimes relaxed and fallen. Nor should it surprise any one, who has observed that there is a natural connection between the shutting of the eyelids and the inversion of the cornea, that both conditions should take place from the same influence,—the relaxation of the rectus externus and of the attollens palpebræ. The relaxed eyelid and the inverted cornea are frequent concomitants, however we may account for it. In every step of the inquiry we shall find occasion to revert to the natural conditions and actions of the eye.

I have just examined a lady who sees naturally well, when the objects are near; but at ten feet off, they are double. The reason is, that the eyes have a due power of converging; but to be directly paral-

* See Halleri disp. Anat. v. iv. De visione qua oculo fit gemino.

lel, requires more action in the abducentes; and they being weak, the parallelism is not perfect.*

I have watched the commencement of a squint in a child, and have observed it from occasional distortion, to the confirmed strabismus. At first, mamma said, "Sir, you are squinting:"—master was stuffing with apple-pie. The occurrence gave it the more interest to me; and the parents being my friends, I watched the boy. When challenged, he could, by attention, look straight; but after a time he lost the power, and a most determined squint was the consequence, which now disfigures the man.

I prefer, when I can obtain it, the opinion of an unbiassed observer. A friend writes—"To-day I had the opportunity of observing an incipient strabismus in a boy of eight years of age, while waiting with his mother in the hall of the hospital. I noticed the squint, which was in his left eye, to be most manifest while he was sitting listlessly, apparently in a day-dream. On calling to him, and having his attention awakened, there was an obvious difference; the squint almost disappeared."

In confirmed strabismus, joined to the distortion there is a defect in the retina itself. When the sound

* The same kind of defect was observed by Sir Everard Home, quoted by Mr Mackenzie on the Diseases of the Eyes. *Diplopia*, and Phil. Trans. for 1797, part i. p. 7.

eye is shut and the squinting eye turned towards you, the sight is seldom strong; very often when you hold up the watch, the patient cannot tell the hour,—perhaps not see the bars of the window. Here a question of practical importance arises—Is squinting purely a defect in the action of the rectus externus: and is the weakness in the retina consequent on the distortion, from want of use? or does the retina participate in the original defect? Is the imperfection of vision concomitant or consequent?

When I examine a true case of strabismus, with the view of determining on the propriety of dividing the internal rectus, I find the pupil turned towards the nose, and after a time it is turned inwards and upwards. This proceeds from the relaxation of the superior oblique, and consequent prevalence of the inferior oblique.

This, however, is no reason against the division of the internal rectus. But let it not be supposed a reason for dividing either of the obliqui. These are muscles provided for the preservation of the eye, and ought not to be deranged.

Every thing tends to shew that, in *strabismus*, the proper and common squint, the defect is in the relaxation of the rectus externus, and that the action of this muscle is impaired, not lost. It is the tendency of this muscle to relax, and not the increased

power of the rectus internus, which is the cause of distortion. Were the action of the first altogether lost, then would the cornea be turned towards the caruncle; and there it would remain, as when the muscle is accidentally divided in a wound.*

In experiments on the monkey, the division of one of the recti muscles gives the ball entirely up to the action of the opponent. That the division of the internal rectus of the human eye, in those who squint, does not cause a distressing squint outwards, is owing to the weakness of the external rectus, and is an additional proof that the defect is there. An intelligent correspondent informs me, that a surgeon having cut the internal rectus of both eyes, the patient looked "like a vicious mare going to kick." This change from the "bull-eye," few would deem a happy effect of the operation.† But such must be the effect of cutting the internal rectus, if the ex-

* The complete division of the rectus externus causes the eyes to turn inwards. See *Sennertus*, as quoted by Boerhaave, *Prælectiones*, T. vi. DCCCXLVI. The man had received a wound in the orbit, which cut the rectus externus. This turned the pupil towards the inner canthus. He afterwards had a wound which perforated his nose; "et totâ vitâ suâ per vulnus et nasum, tanquam opticum tubum, objecta vidit!"

† The bull, when he levels his horns to the ground, has his eyes directed inwards and upwards. In death, especially in bleeding to death, the eyes are so distorted. "Ita Plato ait, Socratem cum brevi ante mortem de anima disseret, *taurinum* inspexisse."

ternal possesses all its power. There are circumstances in the anatomy of the orbit which explain the property in the eyeball of turning towards the nose when the rectus internus muscle has been divided. The orbit is oblique: the foramen opticum is nearer the mesial or central line than the eyeball, and the muscles diverge obliquely outwards to their insertion. By this position the superior and inferior recti have a power over the eyeball when the internal rectus has been divided. If we consider the habitual position of the eyeball in those who squint, it will appear that this action of the superior and inferior recti will be increased.* Such, I apprehend, is the reason that the pupil is not immediately turned out on the division of the internal rectus. It has not escaped the reader's attention, that the united action of the whole muscles of the eye is to turn the pupil inwards, and to squeeze the eyeball to the inner canthus when the organ is irritated.

If the definition of a squint be correct, that the patient sees with one eye only, while the other is distorted and neglected, then he cannot squint with both eyes, though he may squint alternately with one or the other. A patient will look at an object with one eye only, and it is indifferent with which. If the

* See note XVI.

object be on the right side, he will look at it with the left eye ; if on the left, he will look on it with the right. Here there is no defect of the retina, and the abducens muscle of both eyes is weak, and hence the prevalence of the internal rectus in both, so that the left eye is easily directed to the right, and the right to the left side.

In a case of this kind, Dr Darwin supposed the defect to arise from a depraved habit. I think it more probable that the influence, which deranges the action of the rectus externus of one eye, should affect both ; my surprise being that, if the cause be in visceral disorder, and operating through the large connection of the sympathetic nerve with the abducens nerve, both eyes should not be oftener affected. [See note at the end.]

A respected friend and old pupil writes thus :— "The gentleman did not present any appearance whatever of squinting, till about the time when the ladies withdrew, namely, when we may presume the process of digestion was established.

"Both eyes were equally affected, and the squint consisted in each eye occasionally turning too much inwards.

"After much watching, and observing the effect of his directing his orbs (which were unusually prominent) to the objects on the table, I satisfied myself

that he could direct either eye, with the natural degree of power, in any particular direction. But it seemed that, on each occasion of turning his eyes, he regarded the impression on one eye exclusively; that is, one eye appeared fixed in a true line on the object under his view, while the other eye squinted inwardly.

" For example, if he looked on a dish or decanter to his right side, the right eye had the object truly covered, but the left was penetrating to the cavities of his nose, or was turned to the glabellum, and *vice versa.*

" The explanation seemed to be this:—When looking to the objects on his right side, he employed the right eye, as being the one most favourably placed for viewing objects on that side, with a greater amount of volition, or a more positive effort of the will, than the left eye. He preferred, as it were, exercising this eye and attending to its impression, to using the eye situated unfavourably."

My friend proceeds to argue the matter ingeniously. I may state it thus:—The defect is in the rectus externus of both eyes. In looking aside, say to the right, the recti externi are in opposite conditions; the rectus externus of the right eye is active, the strong stimulus of the will is upon it in a state of contraction; the rectus externus of the left eye is

in a state of negative activity or relaxation. It is in this state that it exhibits imperfection, betrays weakness, and relaxes too much; consequently the other muscles prevail, and the eye is distorted inwards. Matters are precisely reversed when this gentleman looks to the left side.

These cases, differing from the common one of pure strabismus, shew that to judge of the precise condition of the eye requires both knowledge and natural acumen, which, as I am proud to say of a pupil, this last communication evinces.

I have the less difficulty in believing that, in some rare instances, the violent crying and convulsive struggling of a child shall produce squinting, because in that state of excitement, what we may call the natural condition of the eye, is exactly that of strabismus; the cornea in passion being dragged inwards and upwards. But, in common cases, every thing tends to persuade us that the defect consists in a certain weakness of the rectus externus. We see a squint produced under a crapulent state of stomach; and at an early period, it is cured by attention to diet and the state of the abdominal contents. As I have just said, the relation between the great class of visceral nerves, the sympathetic, is most direct with the sixth nerve, in its course to this single muscle; so that the deduction from the

anatomy corresponds with our experience of symptoms.*

The more that any one knows of the fine adjust-

* Squinting is attributed to many causes. It is said to be hereditary; and so it may be considered. But the cause is rather to be looked for in the disposition to a certain disorder of the abdominal functions, than to a direct influence on the eye. It is attributed to the position of the infant in respect to light, or to some attractive object; to the habit of looking to its nose; to improper education, &c. All this is misplaced ingenuity. It is equally an error to suppose, that when the eye is defective in sensation, it is left to wander. The distortion is not a *wandering*, but a necessary consequence of a certain defect of the outer rectus muscle, in nineteen out of twenty cases.

In treating of squinting, we must not forget that the muscles of the eye are subject to a variety of derangements; and although the external rectus is most frequently deranged, the other muscles are not exempted.

"Palpebrarum quoque et bulbi oculi, musculi non raro afficiuntur, ubi imi ventris nervi irritantur. Quanta mutatio in oculis infantum observatur quorum prima regio saburra acri repleta est? inordinate et rapide hinc inde moventur, nunc sursum nunc deorsum, abconditis sub palpebris pupillis modo ad latera attrahuntur modo extra orbitam pelluntur, vel intra ipsam deprimuntur; in aliis palpebræ distrahuntur, bulbi figuntur, ut attente objecta aspicere crederes, somno licet correptos hæc omnia horrorem adstantibus injicientia spectacula evanescunt, simulac alvus subducitur, vel vomitu acria expelluntur."—Rahn de miro inter Caput et Viscera Abdominis Commercio, § xiv.

A case is related by Pamard, Journ. de Medecine, t. 23, p. 63, of a spasmodic squint cured by a critical evacuation of the bowels; and Borelli, Hist. et Obs. rar. Med. Cent. ii. Obs. 1, has a case of strabismus occurring in a woman on every recurrence of pregnancy.

ment necessary to correct vision with both eyes, or the more he thinks of the combination of muscles accessory to vision, the greater must be his surprise that an operation so rude as that of dividing one of the muscles, should have the effect of curing squinting. Reasoning *a priori*, one would say, that the effect must be to produce double vision, by bringing the images on the retina nearly, and not absolutely, to a correspondence; and the surprise is rather increased than allayed by the fact, that in some instances it has the effect referred to. Why, then, is it not the same in all? Because the person continues to see with one eye only.

In the last twelve patients whom I have carefully examined, operated on by different hands, one only has vision of the eye which was cut. In that case, the sisters inform me, that she did not always squint, but only occasionally; and, " as mother thought," only when her stomach was deranged."

It is one thing to cure the distortion, another to cure the squint and restore the perfect use of the eye. In the other cases, the individuals do not use the eye operated on. The sensibility of the retina is weak, and the image is obviously not regarded. Perhaps this is a happiness, since in certain instances, double vision has been produced; and to see correctly, the person has had to put his hand on one eye.

The effect of cutting the internal rectus is not to destroy its action finally and altogether; but after a time the divided muscle must form adhesions more or less directly to the eyeball.* In a case seen whilst I am writing, the internal rectus was divided, and I was disappointed in finding no effect at the first. It is now the fourth day, and the distortion is quite removed. We must conclude that the division and reunion diminishes the power of the muscle, and reduces it to that state of action in which it is equivalent to the external rectus, and no more. Its reunion to the side of the eyeball, through the intervention of the cellular membrane, must be attended with considerable curtailment; and the happiest result is when that curtailment and consequent diminution of power correspond with the state of debility in the external rectus.

The subject is highly interesting; the result truly surprising and beautiful. Here is an operation which removes a great striking deformity. We have yet to wait for results: ingenuity has been baffled;

* It is said we have no proof of the reunion of the muscle; but we see it in other instances; at all events, it is pertinent to observe, that some of my friends divide the tendinous insertion, others go back to the belly of the muscle and divide it.—See the last of the additional notes on the action of the rectus superior and inferior.

we must be patient for experience. Let not the operator promise perfect success as to the restoration of vision in the eye. What I have said will, I hope, stay the hands of those who, without reflecting on the distinct action of the muscles, and devoid of the necessary experience, divide other muscles than the internal rectus. Before dividing the internal rectus, let the operator deliberate well on the condition of its opposite, the external rectus. If the affected eye be incapable of turning outwards when the other is shut, let it be ascertained whether this proceeds from weakness in the rectus externus, or from an adhesion on the inner side. Let the operator well consider whether the deformity has arisen from disorder of the muscles merely, or from disorder attended with inflammation and with adhesion.

I am a little sceptical on the subject of adhesion causing a squint, and its division being attended with perfect success. In a common squint there is nothing to produce inflammation and adhesion. The defect is in the muscles. That the internal rectus should be increased in power is not improbable. Nor is it impossible that it should degenerate. But, as in squinting, the weak eye moves freely when the strong eye is covered, it is evident that the distortion does not proceed from that cause.

ADDITIONAL NOTES.

The manner in which I have studied the subject lately, has been to note the cases as they occurred, keeping to the facts simply. The reader may apply to them, the reasoning in the text as an exercise.

I. This young woman desires to know if she should have the "new operation" performed upon her eye.——The left eye squints—not always—it is irregular in its movements—the vision in the left eye is imperfect. She cannot tell the hour with it on my watch—nor see the bars of the window :—when she puts her hand on the right eye, she can distinguish me with the left—on raising the hand from the right eye, the left turns slightly towards the nose.

My opinion is, that the operation will not improve her sight—the squint is not complete—it is more an unsteadiness from want of acute sensation. The effect on her countenance is hardly a blemish.

II. I am requested to decide for or against the operation in this young lady's case. The left eye squints,—it is turned towards the nose, and a little upwards—a confirmed squint. On closing the right eye, she sees with the left, and can direct it fully in the circle. It was after the measles that she was observed to squint.

The feebleness of the impression on the retina is no objection to the operation. I think she should submit.

I saw this lady eight days after the *R. internus m.* was divided—the effect was good—the eye was unsteady ; but nothing to deform an agreeable countenance. The fungus, which sometimes rises in the place of incision, is in this case very large ; having been touched with caustic, it is at present ugly. It will disappear.

III. Mrs —— she squints inwards, not upwards, with her right eye. Sometimes she sees double ; when I retire from her to the distance of nine feet she sees two objects ; when I hold the watch near, she does not see double,—in reading, she does not see double. She says, long before this proposal of cutting for squinting, she wished that something was cut which tied her eye. The eye is large ; it is in consequence of the white part being turned forwards. When I make her cover the sound eye, and look at me, the eye appears to be diminished. She says, the double image is like the double rainbow, one distinct, and the other like its shadow.—*Operate.*

[Eight days had passed.] The eye cut is now direct in the centre—she moves it outwardly to the full extent. It is with pain that she directs it to the nose. On the day succeeding to the operation she felt as if at sea, with an inclination to retch,—the room moved up and down—felt as if the room was unsteady.

There is no such affection as authors describe, where particular objects are seen double and not others: "Ubi quædam tantum modo objecta geminantur, reliquis simplicibus apparentibus." They may see near things single, and far off things double ; because they direct the eyes more easily with the axis converging, than when they are parallel.

IV. This woman is satisfied with the success of the operation. She says, she sees with the eye operated on. She deceives herself as they all do. She squints distressingly. I advised that after a considerable interval, the operation should be repeated with certain precautions.

V. —— ——. His *Rectus internus* was cut in the left eye a fortnight ago. This man's eyes are in a very curious condition. His appearance is greatly improved, but there is a glimmer, which makes it difficult to say which eye is unsteady. He looks at me sometimes with one eye, sometimes with the other. The

eyes do not perfectly correspond. He says he sees best with the eye that has been operated on. This is not true; he cannot tell the hour on my watch with that eye, though readily with the other.

[Second inspection.] He is not improving,—and I suspect he does not see in ordinary with the left eye. He has no double vision. On making him look to the left side, he cannot turn his left eye round to the natural extent. Is this debility of the *Rectus externus*, or adhesion of the *R. internus?*

VI. A fine young man. Operation performed ten days ago. There is now no unpleasant distortion of the eyes—nothing to disfigure, or to be unpleasant in the countenance.

But on carefully observing his eyes, there is a want of perfect consent. The eye operated on is more prominent than the other. The pupil is a little larger. He says he saw double at first. He sees an object as well when the left eye is closed, as when both eyes are open. He was cut on the left eye. The motion of the eye is free in all directions.

VII. A respectable young woman; the eye was operated on by —— ——. It is perfect in all respects. Her sister tells me that she only squinted sometimes; and that mother says, it was only when her stomach was disordered.

VIII. To-day Mr —— brought me two patients on whom he had operated. The results very satisfactory. As he had operated on many, I asked him if he had ever felt the necessity of dividing anything like a ligamentous binding of the eye. He answered, Never; but he thinks that, in some instances, the muscle has been stronger than natural. He divides the muscle, not its tendon.

IX. A fine young woman; the eye operated on, traverses freely—turns freely outwards—squinted at an early period. It was a very bad squint. She does not see double—cannot tell the

hour on my watch. She appears not to attend to the impression on the weak eye.

X. Mr ——. I recommended this young gentleman to submit to the operation. Mr ——, who operated on him, came to me this morning in some distress, on account of no change having taken place in consequence of the division of the internal rectus. He expressed a wish that I should go and see the eye, and determine if he should do any thing more. I said, not now, if the eye is still directed towards the nose; the operation may be repeated hereafter; but nothing can be done now.

Second day from the operation; he tells me the eye has become quite right, and is now directed straight forwards.

Visited Mr ——, and found the improvement as great as in the most favourable cases. *Quær.* Did spasm fix the eye, as I remember to have been the case in my experiments on dogs after having divided one of the recti?

[Jan. 3.] This gentleman and his family are well satisfied with the operation. What I observe is this,—he does not commonly use the left eye. The vision in it is not perfect,—he can use it, and then the sound eye inclines a little inwards. The axis of the eyes are parallel in looking straight before him. But this is not from a just sympathy of action. He can turn the left eye in all directions; but not so far outwards as the right eye is turned inwards. He has no double vision—no pain in looking to the right or the left. His left eyelid hangs a little.

XI. In observing this patient, cut three weeks ago, I find some things not a little puzzling. He says he saw double before the operation: He now sees single! The distortion is cured,—the improvement complete. But as I make him look to the right and left, following my watch, which I hold up, the eye operated on will make an irregular movement, upwards or downwards, or rapidly, first the one, and then the other. He says, the eye operated on is the strongest now.

This irregular movement of the eye is an action of the obliqui —it is like the action of the eye in *Nystagmus Bulbi.* See appendix of the Nervous System, p. 374–5. See De Gorter, p. 250, " Ut et motus instabilis et frequens Bulbi, qui Hippos vocatur."

XII. [By letter.] This lady squinted ; she could by an effort bring the eyes so nearly to parallelism as to satisfy her friends, that she could, if she chose, cure her squint. But when she thus satisfied them, by an effort, she saw double. She submitted to the operation of dividing the *M. Rectus internus.* The eye is restored to a correct position, but she sees double. By an act of volition she can see single ; but then it is observed, that the eyes are distorted ;—What will be the final result ?

XIII. Double vision succeeding the operation for strabismus.

A little boy (C. P.), came to get medicine for his sister. Observing that he squinted, I put some questions to him. Although a decided squint remains, it appears that he twice submitted to operations for its cure. He mentions, that both his eyes originally squinted ; and that in the left eye was much the worst ; nevertheless, he saw clearly. A surgeon, about five weeks ago, operated on this eye ; and the operation has been attended with remarkable success, so far as rectifying the position of the eye is to be taken into account ; for it has now lost all appearance of squint. It was afterwards attempted, by a different surgeon, to make the cure complete, by operating on the right eye ; but the result has proved unsuccessful, for a very obvious inversion of the eye in the direction of the glabellum remains.

The patient, although a little fellow, shews clearly enough that he by no means congratulates himself on having fallen into the hands of the surgeons. He blames them for making his eyesight weaker. He now sees everything double and confused ; and to verify his statement, looks at various objects, and says that there appear to be two of each. He is too young to allow of our

depending on his answers to more difficult questions ; but on the above point he speaks emphatically."

XIV. A friendly critic has observed that I have omitted to shew the peculiar condition of the rectus externus muscle, as exposed to visceral irritation. I have hinted at this, and I thought with sufficient distinctness, elsewhere ; and at different times I have explained more precisely the relation of the great visceral nerve, the sympathetic, to the sixth nerve ; and why this sixth nerve is wholly given to the abducens, or external rectus muscle of the eye. I believe it is through this communication that the abducar muscle of the eye is so peculiarly subject to defect of action from disordered function of the abdominal viscera. See further in the succeeding Essay.

XV. Once more to measure the dimensions and form of the orbit, the position of the foramen opticum with regard to the globe of the eye, and the obliquity in the direction of the recti muscles, I went up to the rooms and dissected the parts within the orbit. But this investigation need not have been made ; for I recollected a plan in Mr John Bell's plates of the Bones and Muscles, which demonstrates beautifully (p. 54) the position of the eyeball, the obliquity of the muscles, and the necessary difference in the length and direction of the straight muscles.*

This position of the eyeball, and oblique direction of all the muscles, is not accidental ; at all events, it is attended with this effect, that when the muscles are excited by irritation of the eye, the ball is drawn towards the os planum. I have noticed that, in this general excitement, the external rectus or abducens is relaxed. But I have here especially to remark, that, by the direction of the superior and inferior recti, they tend to turn the eyeball inwards, and must, when the internal rectus is divided, prevent the eye from being distorted outwardly.

* He quotes Camper, Winslow, Petit ; Academie des Sciences.

If the eyeball should be turned inwards, as in those who squint, the course of these muscles, from their origins to their insertions, becomes more favourable to that action of directing the eye inwards; and this is the reason, I apprehend, that when the internal rectus is cut, the pupil sometimes continues to be turned inwards.

XVI. 20th, This gentleman's eyes appear quite natural. The eye has been twice operated on. The first time the Rectus internus muscle was divided. The second time the internal edges of the superior and inferior rectus were divided. He is a sensible person, and says, as to the vision of the eye operated on there is no improvement. He sees the face of the watch with that eye, but not the hands.

ESSAY IV.

ON THE ACTION OF PURGATIVE MEDICINES ON THE DIFFERENT PORTIONS OF THE INTESTINAL CANAL, WITH A VIEW TO REMOVE NERVOUS AFFECTIONS AND TIC DOULOUREUX.

One advantage of mature years is the means afforded of tracing chronic cases through all their phases. I have seen a patient to-day, with a pain so acute and fixed that I should have concluded it was indicative of deep inflammation, but that I was in consultation on the same patient, for the same pain, sixteen years ago. It is important to our subject, that in all this time there has been no morbid change discernible.

The reader may peruse several cases of painful nervous affections which I published many years ago; and, among others, a case of severe *tic douloureux*.* This patient died last year; when no disease of the nerve affected, or of the brain, could be discovered by the most minute inspection. As the case

* The case of Charles Delafield. Clinical Lecture,—Appendix to the volume on the Nervous System, Case LXXVIII.

was a severe instance of the true *tic*, and as the dissection gives unusual interest to it, I shall transcribe the introduction.

"He presented himself, a miserable object; his head surrounded with a nightcap and rolls of flannel, which almost hid his face, pale and wasted with incessant pain. Seeing him so proper an object of the charity, I gave him a letter and wished him to come into the house. He expressed himself grateful, but he dared not; for he could not bear the restraint even of lying in bed, and had no relief from pain but in continual work in his business of a carpenter. His complaint was tic douloureux, and of that most severe kind which fixes in the centre of the cheek. It came like a flash of lightning upon him. I exhausted my little store of remedies, and still he returned, not weekly, but daily, a miserable object; a study for the painter if he desired to paint 'the last man'—a man despairing."

Last summer when in London, and on visiting the Hospital, I found the same man. Four years he had remained well, and had just returned to seek relief where he had formerly found it. Suffering under the disease, and perhaps of the effect of remedies, he has since died. Mr Shaw made the dissection, one whom, on such a subject, I would trust before all others. The fifth nerve was carefully traced;

the origins of the nerve and the brain examined; but nothing preternatural or morbid was to be discovered. The abdominal viscera were inspected, and there was ulceration of the ilium.

This case may now be contrasted with those in the volume quoted, in which there were morbid changes in the fifth nerve, giving rise to a very distinct train of symptoms.

The opinions which some of the most influential members of the profession have advanced on the subject of neuralgic pains, tempt me once more to recapitulate shortly the distinctions in affections of the nerves of the face.

1. Crowding of the teeth, diseased alveoli and gums, disease in the antrum, will produce pain in the face resembling *tic*,—the rationale being, that disturbance and irritation on an internal nerve will produce pain, referable to the more superficial branches of the same nerve.

2. Disease of the bone through which the fifth nerve passes, or a tumour which involves the nerve in any part of its course, will give pain attributable to the extremity of the nerve, or to the part supplied with its extreme branches.

3. Disease in the nerve itself will produce excruciating pain, referable to the part supplied with its extreme branches.

4. In the true tic douloureux, there is no disease of the nerve, nor of the surrounding parts.

With respect to the first class, I have lately had an illustrative instance. Some of our dentists, in supplying defects, fix the false teeth in such a manner that they cannot be regularly removed and the gums brushed. The gums, no longer exposed to pressure as in their natural condition, become spongy and inflamed, and rise over the teeth. I was called to consultation on a lady in this condition. She made no complaint of her mouth, but of lancing pain in the cheek and temple; and hearing much of tic, she had no doubt of her martyrdom to that disease. The symptoms not resembling those of the true disease, I prevailed on her with some difficulty to shew me her mouth. It was in a miserable condition. On making her remove the case which covered the gums, and unfortunately protected them from the brush as well as the natural pressure in mastication, they had become diseased; they were spongy, fungous, and offensive. The remedy was obvious; and the pains left her as soon as the gums and teeth were restored to a natural state, by the very simple means of a tincture of myrrh and camphor, and the use of the brush with chalk. Before this she had forsaken company and retired in despair.

I cannot resist contrasting with this an instance

of the true tic in the face. I was in consultation with my nephew, Mr G. Hamilton Bell, on the case of a lady, who presented a very singular character of countenance. Although not old, the whole range of teeth of both her jaws had been drawn; and, consequently, she looked prematurely aged.

The singular circumstance in this case was, that although suffering from tic douloureux, when one or two teeth were pulled she had relief; so in course of time they have all been pulled. And now, although teeth, and alveoli, and gums, are all gone, the disease continues. The truth is, that any violent impression will assuage the pain, and fortify the nerve against the remote irritation on which the true neuralgic pain depends. This I believe to be the reason why surgeons continued for so long a time to divide the infra-orbitary nerve, because it gave temporary relief. It may also account for the effect of galvanism in this disease.

With respect to the second class of cases, where the nerve is irritated by passing through diseased bone, the reader may consult a paper on *tic douloureux*, by Sir Henry Halford, in the Transactions of the College of Physicians. In that paper, the author describes the disease as produced by the affected branches of the nerve, passing through the foramina of the skull, and being there surrounded by dead or

carious bone. But, with all respect, I am bound to say, that however severe the pains may be in the extremity of the nerve in such cases, they differ from those characteristic of the true tic; and for a very obvious reason, the cause is continual, and the remission of pain imperfect.

As to the third class of pains in the face,—from disease in the nerve, or a tumour involving it; the distinguishing character is not only the imperfect and occasional, and slight remissions of pain; but such a case will always be distinguishable from tic, by the numbness or total insensibility of the parts to which the nerve is sent. For example, there is insensibility of the cheek and side of the tongue, whilst it is to these parts that the patient is assigning all his torment. The distinction will be confirmed, if the tumour is seated at the roots of the nerve, by the wasting of the muscles supplied by the fifth nerve.

The painful affection of the face, described by Fothergill,* and since called *tic douloureux*, does not affect the function of the nerve; in the interval of pain, the parts supplied by the nerve possess their

* In Observations on Hemlock, second vol. of his collected works. In a second paper on a painful affection of the face, there is that confusion of detail into which the most acute and learned physician will fall, unless he takes the assistance of anatomy.

natural sensibility. The nerve is not morbidly affected. It is influenced by remote irritation; the pain is infinitely more severe, while it lasts, than that produced by the morbid condition of the nerve itself, or of the surrounding parts involving it; and the relief in the intervals of the paroxysm is perfect.

It is this latter circumstance which forces us to look for the cause of pain in the remote organs; whilst the long continuance of the disease without giving rise to morbid structure, imposes the belief that it is owing to disordered function only; and this is confirmed by cures being made through very simple means. That the effects of remedies are not constant should only excite us to further inquiry.

It is difficult to arrange the true Neuralgic pains, —I mean those in which there is no visible disease in the affected nerve.

As to the pain in a remote part, consequent on the disease of the trunk of the nerve, the instances are very many; and the occurrence has become familiar, after the case published by Sir Everard Home; and that which I gave, very early, of a tumour in the popliteal nerve producing pains insufferable in the sole of the foot.* I have since had the

* Museum of the Coll. of Surg. 919. xxii. F. Operative Surgery.

case of Baron D——,* where injury to the popliteal nerve was attended with pains and spasm in the leg and foot; and an additional instance of the effect of a ball lodging on the radial nerve.†

The effect is easily understood in such cases. But why the irritation of one organ of the body should produce pain in a remote part, with which we see no direct nervous connection, is a subject of greater difficulty. Sympathy is an unmeaning word: it explains nothing; it is a mere substitute for sense. Mr Hunter used the term *continuous, contiguous,* and *remote* sympathy. Still, I hold the term to be most unsatisfactory. Mr Abernethy (p. 4)‡ leaning towards him, and, on the hypothesis of Dr Darwin, conceived that these impressions were conveyed to the sensorium, and thence to parts remote from the original seat of disease; Sir Benjamin Brodie inclines to Mr Abernethy; and thus we hold to each other, like men walking in the dark. It cannot be satisfactory to say, that the irritation is conveyed to the fibres of the brain; for why does the pain not return, by corresponding and parallel fibriles, to the same part from whence the irritation came?

* Ibid. 247. xx. E. Surgical Report.

† See a case of the splinter of a ball lying on the median nerve Med. Chir. Trans.; and a similar case referred to by Sir Benjamin Brodie.

‡ On the Constitutional Origin of Local Disease.

In some cases, we can trace the relation which causes remote pains, anatomically; in others, we lose the course of nervous relation, and they appear irregular. A calculus in the kidney or in the ureter affects the testicle and the forepart of the thigh. "The irritating cause, namely, the calculus, operates in the first instance on the nerves of the kidney, through which its influence is transmitted to the venal plexus; and from thence it is, as it were, reflected to the nerves of the testicle."

Such is the fact; but is the rationale correct? There is no reflection towards the testicle. Sensation is invariably propagated in a direction towards the sensorium; not outwardly from the sensorium towards the part. The impression is propagated from the kidney towards the sensorium, and is attributed to the testicle and forepart of the thigh through a false perception.—Does the explanation stand thus? When two fibrils are bound together, the one being disturbed, it communicates an influence to the other, and hence a sensation is attributed to the extremity of that nerve? Or is it, that the painful impression being communicated to the sensorium by a nerve of an internal part (itself not sensible), the sensation is attributed to the external and more sensible cutaneous nerve which accompanies it?

Sometimes the effect of irritation on a sensitive cutaneous nerve, is to cause convulsions in the part supplied by the corresponding muscular nerve. Thus I have found irritation on the fifth nerve, instead of causing pain, giving rise to spasm in the muscles of the jaws. In Sir Benjamin Brodie's valuable contribution to diseases of the nerves, we find convulsion of the lower extremity occasioned by the cutaneous nerves of the groin being stretched over an inflamed gland. Convulsive actions are more frequent from injury to cutaneous nerves ; neuralgic pains arise from internal irritation.

We shall find it difficult to explain how certain general conditions, which we call constitutional disturbance, shall fall with concentrated force on a particular part. Certain structures may be liable to the effects of constitutional disease ; but why should certain parts of the same structure,—particular nerves,—be the seat of irritation or of inflammation ? Why should the fifth nerve of the head, or the ischiatic nerve of the hip, be so distinguished ?

There is another difficulty in some of the cases of nervous pains ; perhaps in the most severe, and the most obscure, the nerve is not inflamed ; whilst in others it is sensibly affected, morbidly sensible on pressure, and inflamed. Shall we hereafter, with better experience, be enabled to make a distinction,

and say, that when, in these neuralgic pains, the nerve has no morbid appearance, it arises from remote irritation? but that, when it is really inflamed, it comes of constitutional causes concentrated upon it? Sciatica, and some forms of disease which I have met with, especially in the fibular and ulnar nerves, differ essentially from the pure neuralgic pain, or *tic*. The nerve is tender,—it is inflamed; in tic, pressure gives relief.* In these cases of inflamed nerve, the pain is severe (as I remember Mr Cline saying) even to death; yet it is different from those sudden flashes and sudden shocks which characterize true tic.

Putting aside the irregular symptoms which attend diseases of the heart and lungs, I shall devote these pages to the remote effects of derangement of the intestinal canal.

The derangement of the first process of digestion in the stomach, produces many affections of mind and body.† But taking the single instance of flatulent

* I offered some interesting cases of this kind in the Treatise on Diseases of the Urethra.

† Ex ventriculo corrupto, sordibusque impleto, crudelissimæ oriuntur cephalalgiæ, otalgiæ, et odontalgiæ, in quibus nil nisi primarum viarum evacuatio proficit.—*Heincken de Morbis Nervorum ex Abdomine.* Dr Woolaston had a peculiarly inquisitive and philosophical mind, so that an observation of his is valuable. He ate some ice-cream after dinner:—when sometime had elapsed, he

distension with spasmodic closing of the orifices, it will produce pain as if the sternum were rent, pain in the axilla and mammæ, and down the side of the arm.

2. Disorder and distention of the duodenum will produce pain, referable to the lower angle of the scapula.*

3. Accumulation in the colon, and consequent disorder, gives pain in the loins, spermatic cord, and groin.

4. Disease of the rectum produces pain in the testicle, the lower part of the scrotum, and inside of the thigh.

5. And disease of the anus, ulceration, piles, and fistula, will be sensibly felt in the schiatic nerve.

found himself lame, from a violent pain in his ankle;—suddenly he became sick, the contents of his stomach were rejected, and there was instant relief.

* Let me recommend the perusal of *Hoffmann de Morbis Duodeni;* not forgetting the paper of Dr Monro *primus*, on this intestine. (Medical Essays of Edinburgh, vol. iv.) I hope when authors speak of disorders of digestion, they mean to include the duodenum. Consider how it is pent in above the mesocolon—how it is tied down by the peritoneum,—how it receives the bile and pancreatic fluids,—and, if they be deranged, how its sensibilities must suffer,—and that, if the digestion in the stomach be imperfect, how this first portion of the intestinal canal must suffer. The old anatomists called it *Ventriculus Succenturiatus*, as performing the second process of digestion, a process subject to many causes of disturbance.

6. Disorder of the covering of the testicle will produce pain in the loins and cord; and disorder of the body of the gland has intimate relation with the stomach.

7. Disorder of the uterine functions, as irregular menstruation, conception, pregnancy, and labour, whilst they exhibit the sympathy of the uterus with the mammæ, affect the spine and muscles of the back. Many a young woman suffers from the ignorance of this relation between uterine irritation and pain in the back. Weariness and languor, and a singular degree of morbid sensibility, attend the disorder, and the sensations are erroneously attributed to disorders of their spine.

These pains, comparatively external, may be reduced to a law, viz. that irritation on the internal branch of a nerve, by disorder of function in the viscera, will be felt or attributed to the external branch of the same nerve. It is the same law by which inflammation of the liver will be recognised in the pain of the shoulder.

But I proceed further, believing that irritation in certain parts of the canal, produces neuralgic pains in more remote parts;* and that one character of these

* In this all authorities agree: Vogel, Hoffman, Whytt, Sydenham, &c.

sympathetic pains is their recurrence depending on the process of digestion.

I have been seeking for a case,—I think in Portal,—which made an impression on me in my earlier studies. It was a distortion of the spine, in which the point of the lower rib pressed upon the intestine, producing pain in the lower extremity, not constant but intermitting, and depending on the fulness and rising of the gut against the point of the rib. I imagine that, in some instances, the recurrence of pain proceeds, not from the periodical revolution of the system, to which physicians attribute the intermission and exacerbations of fever, but to the stage of digestion and the part of the intestinal canal then under action.

Mr Abernethy speaks of his examinations after death, and discovering that the intestines were subject to partial inflammation : "the villous coat was found swollen, pulpy, turgid with blood, and apparently inflamed." His object was to shew, how general irritation may fall on the intestine, producing disordered action elsewhere. I take this as an established fact, and draw an inference from it.

When Sir Astley Cooper lectured before the College of Surgeons, he exhibited the intestines of a dog, which had been fed some hours before. The chyle was exhibited adhering to the surface of the

jejunum, and the corresponding mucous coat in a high state of vascularity. This was the excitement of a part during the performance of its natural function; and but for that consideration, we should have called it inflammation.

My reader will draw the just inference. In the progress of assimilation of food, distinct parts of the intestinal canal are brought successively into action; it has also to be recollected, that this canal is estimated to be in length seven times the height of the body. Is it, then, an extravagant conclusion, that a morbid condition, or irritation, or functional disturbance, may take place in this canal, causing pains of remote parts, and that they shall vary according to the part of the mucous membrane under disturbance?

These considerations bring me to my subject; which is the effect of purgatives in curing remote and irregular neuralgic pains.

Turn how we may, we find the recommendation universal, of evacuants or purgatives for such disorders. Still the question is; Is the rationale correct? We find by the terms used, that the evacuation of offensive matter is the general idea. *Vitiosa primarum viarum—colluvies—sordes—saburra vitiosa,* are terms in common use, and the object seems to be the mere evacuation of the canals, or the removal

of what clings to their interior, such as we see in a foulness of the tongue.

In the first place, we must recollect that the abdominal viscera are not merely incidentally collected and grouped. They are not allied by mere juxtaposition, but are as intimately bound together by nervous relations as the heart and lungs in the thorax, or the brain and the organs of the senses.

There is no disorder of stomach or bowels strictly local or limited. The various secretions which are poured into the canal, into the stomach, or duodenum, are furnished under the influence of the canal, and are as necessarily deranged as the action of the bowels themselves, when under irritation. The mere evacuation of the bowels appears to remove many disorders; but evacuation implies not only the muscular action of the canal, but vascular excitement, and the pouring out of secretions from the mucous surface; and more than that, from the subservient glandular viscera. Such a view implies purging into the intestinal canal: the relief to secretions which are pent up. If we look to cases,—and more especially those which are called Nervous Affections—the cure has been preceded in many of them, not merely by the discharge of the bowels, but by dark and fetid evacuations, in quantities to make the practitioner express his surprise from whence it came.

These are attended with a subsidence of the tension of the upper part of the abdomen, and relief of sensations, difficult to express, in the præcordia.

Such are the considerations which impose upon the physician the use of certain medicines, which we may call alteratives, or what we please,—but, essentially, they are those which operate on the secreting organs,—those which pour their contents into the intestinal canal. Then it is, that free evacuations, by purgatives, have such surprising effects as authors delight to dwell upon.

Mr Abernethy's practice of administering blue pill, combined with bitter aperient, was happily conceived and illustrated. When I went first to London, I was surprised that it should make so great an impression by its novelty, seeing it was so near the practice acted upon extensively in Scotland, under the recommendation of Dr Plummer.* The use of small doses of emetics and of purgatives,† or the combination of the oxysulphuret of antimony and guaiacum with calomel, joined to the diet drink, being so well known among us, it surprised me to find the *town* taken as with a new discovery. But Mr Abernethy put his practice on true pathological

* On Alterative Mercurial Medicine. By Professor Plummer. (Med. Essays of Edinburgh, vol. i. p. 42.)

† Ibid. vol. v. p. 62.

principles, when he said, "I think it probable that the profuse discharge which sometimes follows the continued exhibition of purgatives, consists of morbid secretions from the bowels themselves, and not the residue of alimentary matter detained."

The action of a vomit is not the mere evacuation of the stomach, but the diaphragm and abdominal muscles, indeed, the whole class of respiratory muscles, from the groin to the glottis, are highly excited and in action; the abdominal viscera are compressed and agitated, and the secretions are poured out. Hence, surely, it is, that a vomit acts so surprisingly in the removal of many complaints.*

Even the mere excitement of secretion, by smaller doses, which do not bring the muscular system into action, has powerful influence.†

In regard to the intestines, also, I need hardly point out here, that the canal cannot be excited without an increase of activity in the whole extensive arterial system of the abdomen; that the blood is consequently urged forwards in all the branches leading to the vena portæ; that the blood thus urged into the liver must as certainly excite to the secretion of bile, as the increase of respiration excites the lungs

* Hoffmann de motu ventriculi convulsivo sive vomitu. Fothergill Dissert. de Emeticorum usu.

† Med. Essays of Edin. vol. v. p. 75; ibid. p. 162.

and heart; that by the pouring of bile into the intestines, as their natural purgative, the circle of relations is completed; the action and reaction that take place when the bowels are stimulated.

If this view be correct, it is imperfectly conveyed in the valuable work of the late Dr Hamilton. There is too much said of "fæculent accumulation,"—there is something too mechanical in the notion, that in females the hinderance to effectual evacuation is in the form of the pelvis [p. 138]; yet, practically, it comes to the same thing, since he persevered in the use of purgation until the whole abdominal system was in due activity.

With respect to these neuralgic pains, circumstances have impressed upon me the belief, that the true *tic*, though remotely seated in the branches of the fifth nerve, has its source in the intestinal canal.

I do not offer the croton oil as a specific in this complaint; but its effects have been so remarkable, as to afford a ground of argument. I ordered it at first in desperate circumstances in the most severe case of pain in the cheek; and the effect being immediate, the relief perfect and permanent, I should have been to blame had I not followed the practice in similar cases. In very many it had the same happy result.

What then, I may ask, would be the conclusion

of any inquiring mind, when he found a peculiar purgative acting powerfully, but not more powerfully than other forms previously given, attended with immediate and permanent relief of symptoms? Mine, I confess was, that it acted directly on that portion of the canal, the irritation of which, or as Mr Abernethy would have said—"the discontented state of which," produced the remote pain.

I have referred to a patient who had been subject to tic douloureux, and who had been more than once cured of his pain by croton oil, having died last autumn. There was no disease in the nerve, but ulceration was found in the mucous coat of the ileum. But then it is said in the report conveyed to me, that he had been too powerfully dosed with this medicine. I take the facts either way; the ulceration was the cause of the *tic*, or the ulceration was occasioned by the medicine. In this last supposition, we have the important admission, that croton oil improperly used, will act on a portion of the mucous coat to the formation of ulcer. Could we depend on this reasoning, it would explain how the better regulated administration of the medicine did, in very many cases, affect a portion of the intestine to the removal of morbid irritation there.

Reviewing my experience, I think I am borne out in believing, that the disturbed function of particu-

lar parts of the intestinal canal gives rise to pains differing in their apparent places according to the portion of the canal irritated. Here I conceive there is a wide field for inquiry. If the intestinal canal is estimated at seven times the length of the body; and if it be also acknowledged, that the different portions of this long tract of mucous membrane perform distinct offices, and are subject to different influences, there is nothing to repel the idea, that those portions being in a condition of disturbance and irritation, shall produce a variety of symptoms, especially differing in their apparent locality.

And this view is countenanced by the effect of medicine. We can throw the influence of evacuants on the different portions of the canal,—affect the stomach, the duodenum, the long intestine, the colon, or the rectum. Thus is each portion of the intestine proved to be distinct in office, and to possess distinct affinities.

It is on this principle that we ought to pursue the inquiry,—*first*, on what part of the extended canal does this secret disturbance fall; and, *secondly*, what form or combination of medicine shall especially touch or influence the part affected. We have an instance in the effect of the croton oil. Let

us not call it a specific, but seek for other remedies, on a just and scientific principle.*

* Some of my pupils have been very successful in using the croton oil.

Dr Newbigging junior, gives a short paper in the Edinburgh Medical and Surgical Journal, No. CXLVI., on the croton oil employed in nervous affections with remarkable success.

Note.—Looking back to my successful cases, I have never found it necessary to give more than $\frac{1}{12}$ of a drop in combination. Others, by administering oil not genuine at one time, and an over-dose of true croton at another, have done great mischief.

THE END.

EDINBURGH, PRINTED BY NEILL AND COMPANY, OLD FISHMARKET.

PRACTICAL ESSAYS,

BY

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EDINBURGH:

MACLACHLAN, STEWART, & COMPANY.

MDCCCXLII.

PREFACE.

It is an old expressed opinion of the Author, and countenanced by the authorities of the past age, that Surgery can be taught only in intimate connection with the Human Anatomy; yet, in the great Institutions, these departments are separated. Anatomy, as taught, by the Physician, is a great department, full of general interest, and leading to deductions of the highest importance, both in relation to Natural History on the one hand, and to Pathology on the other; its connection with general science is indeed of unlimited extent.

But whilst Anatomy in this view is seductive, there are severe lessons, and of vital importance, to be drawn from it, and these can only be appreciated by the Surgeon. It is these latter subjects, which the Author seeks to illustrate by these Essays;—to shew that, between the naked demonstration of the anatomy and the knowledge of surgical diseases, there is, in the present

mode of teaching, a chasm, or rather a field left, which, more than any other, requires cultivation.

The Author had intended to give some observations on the Sympathetic Affections of the Chest; but, on turning to the late writings on the nerves of the chest, he found the opinions undetermined and contradictory. He has, therefore, been induced to give, in the first place, a view of the functions of these nerves. That he has at the same time, and at this time of day, been led to vindicate his original observations, will not be imputed to him as a fault, and he hopes he has not done it offensively.

AINSLIE PLACE,
February 1842.

PLATE I

Fig 1

Fig 2

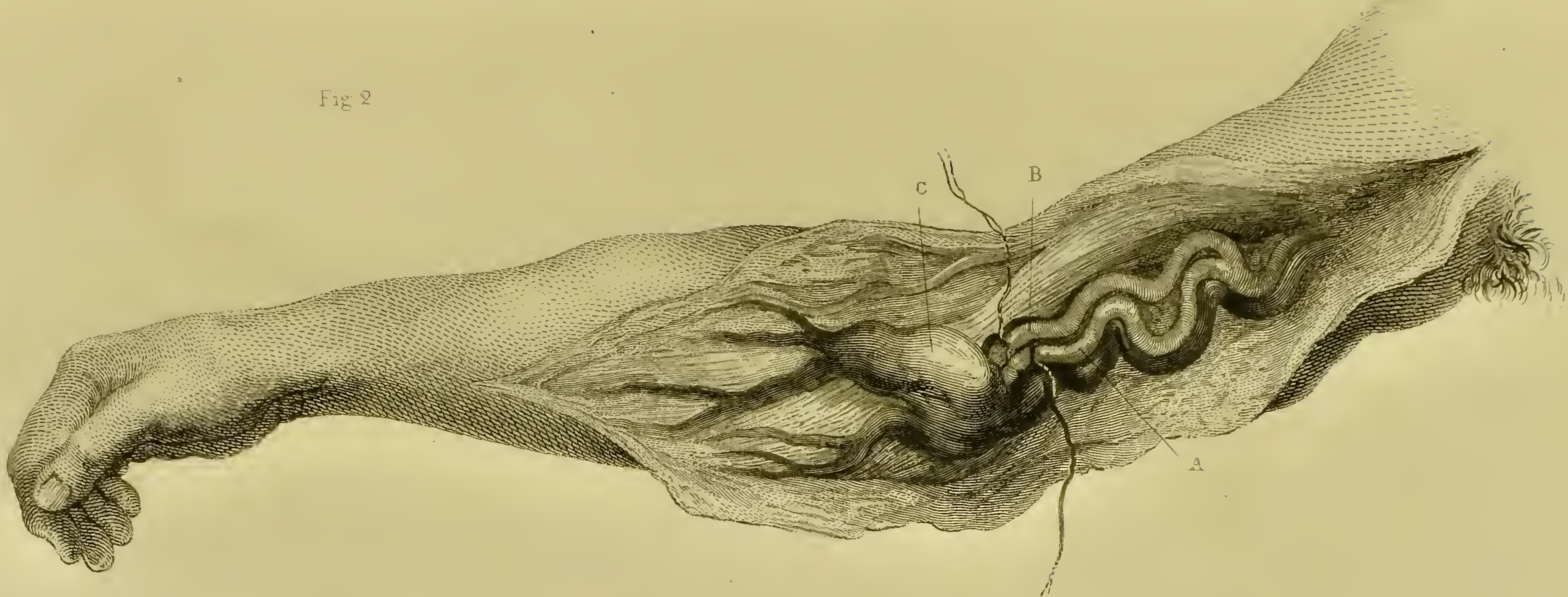
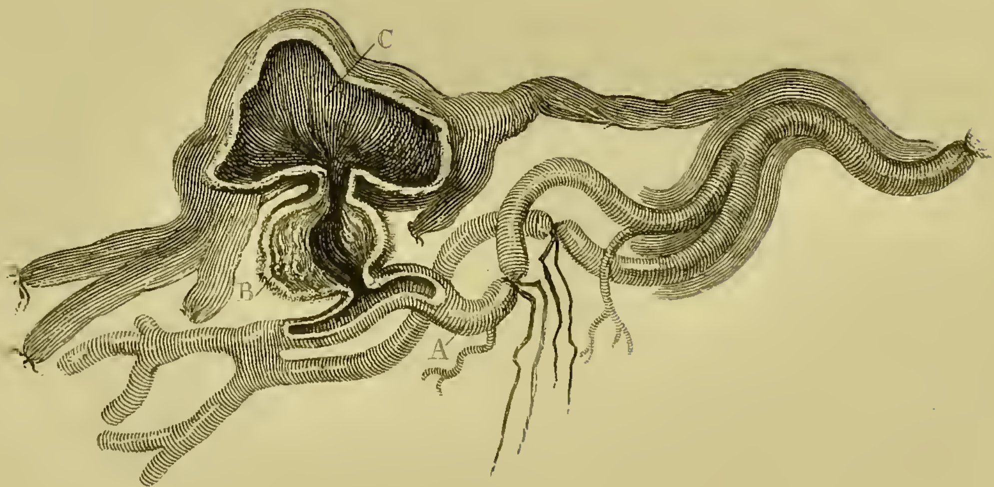


Fig 3



EXPLANATION OF PLATE I.

Fig. 1. This was a drawing, from the arm with Varicose Aneurism; the lancet having passed through the median basilic vein, and opened the radial branch of the humeral artery. When there is a high bifurcation of the humeral artery, the radial division runs obliquely across and under the vein, and very superficially.

Fig. 2. Is a drawing from the dissected arm.

A, the Ulnar division of the Humeral Artery.

B, the Radial division of the Humeral Artery. Ligatures are on both the arteries; and both arteries are remarkably enlarged; still more remarkably tortuous.

C, Is the Median Basilic Vein, greatly dilated, from receiving the blood directly from the artery.

Fig. 3. The vessels taken out; so as to shew the combination of Aneurism with Varix.

A, The Radial branch of the Artery.

B, The Sac of the Aneurism, exhibiting layers of coagulable lymph. The aneurism was formed under the fascia; that it did not increase, was owing to the freedom with which the blood found a passage into the vein. That passage made by the puncture of the lancet, was probably kept open in the first instance, by a coagulum of blood, which, being brushed away by the force of circulation, the communication became permanent, and so formed the peculiarity of the case.

C, The Median Basilic Vein, enlarged into a sac.

EXPLANATION OF PLATE II.

Fig 1. Is a view of the Femoral Artery and Popliteal artery dissected out of the limb of a patient who had been operated upon, for popliteal aneurism, by the author.

He made the incision across the upper edge of the Sartorius muscle, raised the edge, dissected the deeper fascia, found the artery in its proper place, felt it pulsate, and put a ligature round it. After the operation, pulsation was still felt in the ham; but, confident that he had tied the artery, he did no more. Next day the pulsation in the tumour had ceased. But after a few days the fever of irritation struck up; a swelling, of an erysipelatous character, extended upwards to the superior spinous process of the ileum, obviously in the track of the Sartorius Muscle, and the patient sank. On dissection, this singular distribution of the femoral artery presented: the artery divides into two trunks which run parallel, and are again united as they pass through the triceps muscle. The circumstance which the preparation illustrates is, that, notwithstanding that only half the force of circulation was cut off by the ligature applied on one of these divisions, yet it was sufficient to cause the blood to coagulate in the sac of the aneurism, and, but for the fever, the cure would have been accomplished.

A, The Crural Artery at the Groin.

B, The Profunda.

C, The Femoral Artery divided into two.

N. B.—The clot in the artery, which had been tied, is of unusual length.

PLATE II

Fig 1.

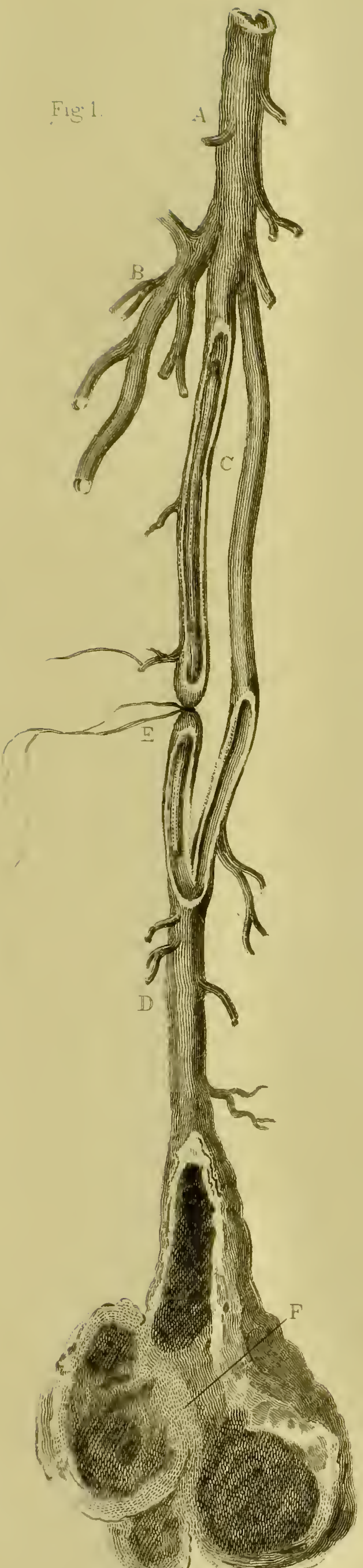
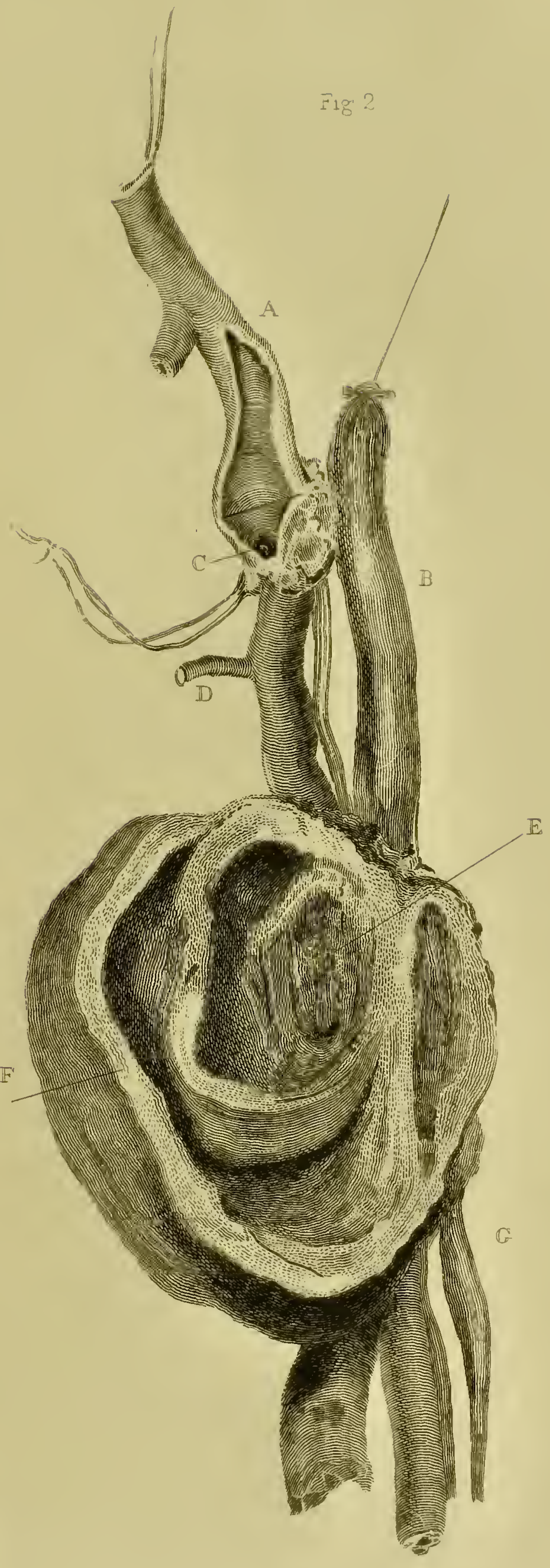


Fig 2



D, The Popliteal Artery.

E, The Ligature on one of the divisions of the Femoral Artery.

F, The Aneurismal Tumour of the artery in the ham, entirely filled with coagulum.

Fig. 2, Represents an Inguinal Aneurism. The patient, when brought into the hospital, had a small pulsating swelling in the groin: a distinct aneurism. The consultants resolved on immediate operation. For some reason, certainly not a cogent one, the operation was delayed, when suddenly the swelling enlarged, and the pulsation became stronger, and then the operation was performed, and in the manner Mr Abernethy had suggested. In pushing up the peritonæum it was torn; the hole was quite minute, sufficient, however, I believe, to bring on peritoneal inflammation. Abdominal inflammation did arise, and the patient was lost.

A, The External Iliac Artery.

B, The External Iliac Vein.

C, The Clot, a very small one, above the ligature of the iliac artery. The reader will make a comparison of the very great difference in the clots in fig. 1, and in this case.

D, The Epigastric Artery.

E, The original Sac of the aneurism, and the artery opening largely, into it.

F, The Secondary Sac or Aneurism formed in consequence of the rupture of the first.

G, The Crural Nerve engaged in the condensed cellular membrane forming the sac; from which circumstance, we comprehend the nature of those pains which affect the lower extremity in the course of the nerve.

EXPLANATION OF PLATE III.

In illustration of the Exercises to correct the Lateral Curvature of the Spine.

Fig. 1, Is an outline, representing the common appearance of a young lady with *lateral* or *sigmoid* curvature. We may notice the high right shoulder—the contracted position of the scapulæ or shoulder-blades—the convexity of the dorsal portion of the spine towards the right side—the fulness of the loins on the left side of the vertebræ of the loins, and the depression on the right—and the suddenness of the *twist* at the lower part of the back.

Fig. 2, Is to shew the effect of the proper use of the clubs, in giving exercise to the spine. The club hangs perpendicularly from the tips of the fingers. It is not swung round the head, but the body is so bent, that the head passes under it without touching the club; this can only be done by exercising the flexibility of the spine; the club is shifted from one hand to the other, and so alternately carried round, first on the one side, and then on the other. These exercises should be used often, and at least on dressing and undressing, when the body is disencumbered by stays, or such parts of the dress as may check the free motion. This exercise is more especially intended to correct the spiral twist of the vertebræ.

Fig. 3, Represents the simple preparation for another exercise, which may be made in the school-room. The figures represent the exercise of the sawyer, by which the long muscles of the back are fully exerted, and all the apparatus of bone, ligament, and muscle connected with the spine, are exercised.

Fig 1

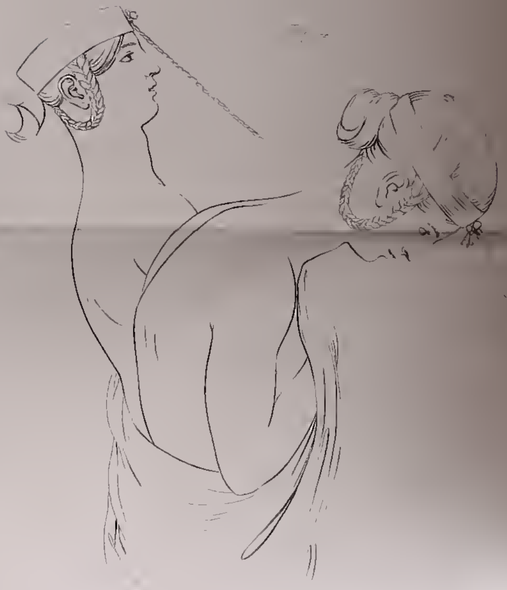


PLATE III

Fig. 2

Fig

Fig 5.

Fig 3

Fig. 4, Is another mode of using the pullies ; a band is put round the head, and the cord is attached to it. The young lady crossing her hands before, allows the head to be drawn down by the weight, then raising herself, she throws the head fully back, erecting and extending the spine.

N. B.—The weight is a bag of shot, in which there is more or less, to suit the age and strength of the patient.

Fig. 5, Represents the patient lying on the inclined plane. It consists of two boards gliding on wheels, the upper one is now fixed, the lower one let loose ; the consequence of which is, that the inferior part of the figure tends to slip down, and thereby the spine is gently and uniformly stretched. The head may be fixed by the occiput or back part of the head, fitting into a concavity or socket in the upper board ; and then a ribbon or handkerchief under the chin, and around the head, may be attached to the upright post. This will prevent the shoulders from gliding down.

By so slight a means of retaining the head, there is no danger of distorting the face.

Fig. 6, Represents the manner in which the inclined plane is used to exercise the spine. The upper portion of the plane is taken off, and the lower part being on wheels, the young lady lays herself upon it, and holding by the fixed handles, she draws herself up—at the same time raising the head, and throwing the whole head and shoulders back, so as to give exercise to the spine.

With the proper inclined apparatus a great variety of exercises may be performed. She may use one arm in a manner to expand the left side of the chest. She may lie on the back and still raise herself, or she may go through the same exercises which are indicated in figures 3d and 4th. The patient should

be provided with a loose flannel dress for these exercises. The maid should be taught to rub and champoo the spine and sides, whilst her young mistress may be fatigued, and rests before resuming her exercises. These exercises, and the friction of the skin, conduce remarkably to health.

N. B.—On page 123 is a view of the skeleton with lateral distortion. The young woman died of typhus fever. It was remarkable that, on examining the skeleton, though it presented the appearance we now see in this figure, yet it could be moulded into the natural form; but when the hand was removed, the spine returned, by elasticity, into the lateral curve. This shews how much the ligaments and cartilages partake of the derangement, in the early stage of the lateral curvature.

PRACTICAL ESSAYS.

ESSAY V.

A VINDICATION OF THE NERVES OF RESPIRATION AS A DISTINCT SYSTEM.

THE intention of the Author as announced, was to have confined himself to practical remarks on the sympathies which render the diseases of the chest obscure—his original title being, *on the Eighth pair of Nerves, and the difficulties they occasion in distinguishing nervous derangement from organic disease.* But on taking up the papers which have been of late written on the Nerves, of which the *Par vagum* is the centre, he finds that much has been misconceived, and with not a little bias to misconstruction. He is therefore rather unexpectedly called upon to vindicate that arrangement which made him describe certain nerves under the denomination of the RESPIRATORY SYSTEM.

The contemporaries of the Author's early labours are removed from the stage, and the youths whom he superintended are bald and grey; and it is not easy to carry back the minds of this generation to the opinions held, and to the condition of the schools, at the time he commenced the investigation into the nervous system.

The simplest proposition that was ever brought before a learned body, regarded the Symmetrical or Spinal Nerves. It has taken just thirty years to satisfy the profession of the correctness of that system; nor would it now be acknowledged, but for the more minute investigation and the more liberal spirit of foreign anatomists.*

The same fate seems to attend the system of Respiratory Nerves; and I fear that most authors have not taken the trouble to peruse my original papers, but have trusted to the representations of those who have themselves misapprehended the subject.

The great features of the two systems are the same, and the one is consequent upon the other. The Author will keep to his original designation of these two systems; for among other contrivances to give the semblance of originality, is the use of new terms, where there is nothing new; and first, as to—

THE CIRCLE OF THE NERVES.

Connected with this inquiry is the sense of muscular exertion. Convinced by observations that there was an inlet to knowledge of things external beyond the

* On this head I am much indebted to the Recherches Expérimentales et Pathologiques, par F. A. Longet, Paris.

sensibilities of the proper organs of sense,—and that our perception of things external belong to the motions of the body,—it became an object with the Author to ascertain how we possess the knowledge of the condition of the muscular frame. Is it a sense of the effort made in putting the muscles into action? or is it a sense of the actual condition of the muscle during the action, and previous to it? It was in pursuing this subject that he became convinced that every muscular exertion or action is regulated to the most minute degree by a sense of the condition of the muscle; that in moving after repose or sleep, it could not be the recollection of an effort made which directs the action; and, therefore, that there must be a sense of the condition of the limbs, and that that sense is independent of the organ of touch. The discovery that each muscle has two cords,—that one of these is motor and the other sensitive, became of high interest. Here were the means afforded of that consciousness of the condition of the muscles which is necessary to regular activity—a regulator of the actions. This was the foundation of his paper to the Royal Society of London on "*The Circle of the Nerves.*"

The half of his proposition has been appropriated under the term of *Reflex action*; by which the high interest which should belong to it has been obscured. What they fix upon is this: That on irritating a part,

motion is produced, not by an influence direct on the part moving, but by a power conveyed inwards by the sensitive nerve, and back, or in a direction outwards, by a motor nerve. Here, surely, might have been an occasion for some acknowledgment; since, who was it that showed them the existence of such distinctions in the nerves? But it is of more consequence to shew how partial and how poor an account of the matter this is; for by excluding the other part of the proposition, that there is an entire circle, they lose sight of the most interesting view of the economy of the animal frame.

In contemplating this circle, whether the action takes place by a mandate of the will, and passes outwards, or arises externally and by irritation, and passes inwardly, there is still an operation in a circle, and thereby an intimate relation between the sensorium and the instrument in operation. There is an intimacy of relation between the sensitive and moving parts of the whole frame, till then unthought of.

It has been the Author's intention at all times to distinguish what he had proved from what he had conjectured. It was a conjecture only, but drawn from human and comparative anatomy, that the plexus of nerves was the means by which the relations of the muscles of the extremities were arranged in classifications. It was a conjecture only, that what is called

the decussation of the columns of the medulla oblongata, were of the nature of plexus, and that by it the relations between the four quarters of the body were arranged. But it was no conjecture, that, independently of the brain and all mandates of the will, there were relations established in the body; nay, that even the decapitated body retained within it the means of arranged actions. This he was wont to illustrate by the danger the knacker ran, after bleeding the horse to death, of having his brains knocked out by a kick of the horse in flaying him, unless he had put down a skewer or rod through the tube of the spine to destroy the spinal marrow, this being a concatenated or regulated action of muscles (not a mere convulsion), and resulting from the relation of the cutaneous nerve with the nerves of motion established in the spinal marrow.*

The doctrine of animal life and organic life tends to

* Touching the completeness of the system of nerves of the spinal marrow, I may say here, that when we trace the columns upwards into the brain, there is a field of surpassing intricacy; and the most noted speculator may find circumstances in the Anatomy which apparently vindicate his opinions. When the same side of the face is affected with that of the body in hemiplegia, it may be explained in two ways; either on the supposition that there is a decussation above the pyramidal bodies, or that a portion of the roots of the *portio dura* are derived from below. I confess myself of this latter opinion. See how the question is put by M. Longet in his *Recherches Expérimentales*.

retard the spread of a better knowledge of the nervous system. The mere presence of a nerve implies a relation between sensibility and motion. While it combines muscles, it infers a centre from which an impulse emanates towards the moving apparatus, and this takes the function out of the category of organic life.

What has further tended to the misunderstanding is, not want of ingenuity, but a fancy that overshoots the mark. Instead of being satisfied with the study of the fabric, the foundations of the structure, and the means of motion in the animal machine, authors must tell us how the mind operates. The connection between the actual sensibility or consciousness, and the automatic condition of the body, is a subject in which many lose themselves. Take, for example, the sensibilities of the intestinal canal,—a matter not foreign to our present investigations, as shewing the difficulties which they encounter who go beyond the limits of the subject.

In the throat there is both instinctive action (by which I mean an action without choice or reason) and a sense of enjoyment and volition. The action begins in consciousness, and volition proceeds insensibly and uncontrolled; and by many changes in the mode of action of the muscular fibre, the ingesta are propelled, until, on approaching the lower extremity of the intestinal canal, sensation once more joins in

combination with the silent excitement of the parts, and volition is superadded to mere orgasm.

Similar relations are perceived in the organs of breathing, those exerted in vomiting, expelling the urine, &c. In all these there is a centre on which an impression is made, and from which a diverging impulse is conveyed and muscles associated, and the operations of the economy are silently or unconsciously performed. But there is not one of them, when in excess, or on occasions, but produces sensation in its ordinary acceptation. It may be an inquiry how this change is induced, whether through the participation of the regular system of sensible nerves, or only by a higher condition of activity of the nerves which, in ordinary circumstances, rule these internal operations.*

At any rate, these abstruse questions on subjects which, I really believe, are to continue hidden, do not touch the matter at issue.

The reader, I hope, will not be offended by the homeliness of the following illustration. Philosophy may contemplate the meanest thing. Looking into a

* The sensibility of the membrane of the cavity of the nose, which results from the distribution of the fifth pair of nerves, would lead me to believe a direct relation established between the symmetrical and respiratory systems; since my cases shew that when the sensibility of the Sneiderian membrane is lost by disease of the fifth nerve, sneezing does not follow irritation of the membrane.

butcher's stall we see there a sheep divided through the chine, presenting what we call a section of the animal. There hang on an opposite peg, the exviscerated parts, or say, the whole contents of the chest.

Now, in the separation of the viscera, there is no part touched or broken in upon, and the parts hang together grouped or agminated. On the other hand, the carcass is entire, consisting of a compages of bone and muscle, and designed to move in the act of respiration. The carcass is the moving apparatus; the viscera, though in their place, are passive.

The question to be solved is no more than this: What sensibilities are there in the contained parts, and how do these sensibilities put in motion the exterior apparatus? In the tearing out of the contained from the containing parts, membranes only are torn, there is no breach of surface in the viscera themselves; —by what sympathies are they joined together, and especially by what living bond are they so united to the moving apparatus, as to produce action there, corresponding with their sensations, their wants?

I here beg to observe, that such a general survey as this is not necessarily a superficial view; nay, on the contrary, it may decide the main question. There is a cord or nerve which passes down through the whole mass of these viscera. We must suppose it capable of conjoining them as living parts more intimately than

by juxtaposition. At any rate, we know that this nerve bestows sensibility. It was indeed superfluous in me to state that a man paralytic from a fracture of the vertebræ of the neck, is sensible to pressure on his stomach, since we know that there are sensibilities differing in kind as in degree, and suited to the government of the functions. This nerve being traced upwards, we arrive at a point near the head, from which nerves diverge to the whole carcass, or rather to the muscles which act in breathing; and thus the sensibilities of the parts *internal* of the chest are joined to the moving apparatus *external*. This is surely simple enough.

The central nerve is the *Par vagum*;* the diverging nerves are the *Portio dura* of the 7th; the Glosso-pharyngeal nerve; the Spinal accessory nerve, and the Phrenic nerve. Now, if by irritating this great central nerve the *par vagum*, the others were excited, and by their means the whole apparatus of movement put in operation, what would an unprejudiced mind conclude? These I designate Respiratory Nerves, and I am now prepared to maintain them such.

One might have imagined, that when a system of

* *Par vagum* is an unexceptionable term as indicating the extensive course of the nerve. Pneumo-Gastric is the very common name. But it neither indicates its distribution to the larynx, nor its prolongation into the solar plexus.

nerves was proved to extend from top to toe, ministering to sensibility and voluntary motion, and of perfect regularity, undeviating in their composition and mode of origin—in their distribution and functions;—that authors, seeing a different set of nerves irregular in comparison, and differing in their origin and distribution, would have inquired, what system of parts, what sensibilities, and what motions, are superadded to the voluntary system of the animal frame: And, if they could trace these very nerves to parts having motion independent of volition; active in sleep; active in apoplexy; the last to die; and that these motions are stopped by injury to these nerves—that they would not have rejected a view which was countenanced by so many concurring circumstances.

Physiologists have sometimes taken the old road to error, experimenting on living animals without due attention to the functions. Had HALLER experienced and reflected on the pain of a sprained ankle, he would not have declared that bone, cartilage, ligament, and tendon were insensible parts. He would not have left it to others to mark the beautiful provision in the economy of the living animal, that sensibility differs in kind as in degrees; and if I instance the celebrated Baron HALLER, to whom we all give honour, it is to obtain the privilege of criticising friends, withou inferring want of respect.

I hope it is known that I am no favourer of experiments on living animals, which amount to the dissection of the living. It might be weakness, or enthusiasm, or fanaticism, but I believed that Providence would not favour discovery by protracted cruelty to animals; and reason dictated, that after distinctions had been discovered in what were termed common nerves, and that these distinctions were dependent on the roots or origins—that all which it was possible to reach might be obtained by anatomy strictly. Even now, after perusing the experimental dissertations which the schools of Europe have put forth, I firmly believe that all the information we have obtained might have been attained by the study of function, and the dissection of the dead,—a method, no doubt, not so well suited to the impetuosity of youth, and requiring patience, watchfulness, and a philosophic mind.

I shall take one of the nerves of this system, the Glosso-pharyngeal Nerve, to illustrate my meaning, and as shewing the necessity of studying functions. The sensibility of this nerve is as fine and as distinct in its nature as any of the nerves of sense. But experimenters puzzle themselves, and commit many cruelties to ascertain whether or not it is a nerve of taste. Although experiments upon themselves might have sufficed to shew that the papillæ of the tongue are the organs of taste, and that they are furnished with

branches of the fifth nerve—is it not a strange oversight to neglect that sense which resides in the root of the tongue and fauces, which calls for gratification more imperiously than the sense of taste? What was it that made the Roman eat to repletion, vomit, and return to the feast?* Could his appetite be satisfied, by tasting, masticating, and spitting out the morsel? Is there not an ungovernable desire to swallow as well as to taste? The desire is not sated by having the morsel in the mouth; it must be thrust backwards, and there it is seized by the *Constrictor isthmi faucium* and *Palato-pharyngeus*. Those muscles commence that series of uncontrollable actions in the gullet which propels the morsel into the stomach. Thus it is that Nature, like a kind nurse, provides for the necessities of the system, even against the tide of passion and the resolution to die; for few, like Atticus, have been able to resist this natural sense or appetite, and have

* There is something in this practice of taking vomits before and after meals which we cannot understand. SENECA says, they vomit that they may eat, and eat that they may vomit. It is also reported that the Athletæ of Rome used the same practice to strengthen them. Our boxers, in training, are purged. See CICERO *Attico*, in which he mentions Cæsar taking a vomit before dinner as a compliment to himself, as if he said, I know I am about to be well entertained, and see, I am prepared! VITELLIUS survived all his gluttonous companions by regularly emptying his stomach after inordinate indulgence.

succeeded in this mode of suicide.* This sensibility possessed by the root of the tongue and fauces is the appropriate office of the glosso-pharyngeal nerve.

What, then, it is asked, has this to do with breathing, and why should we call it a respiratory nerve? Can deglutition and breathing go on together? Is not the act of respiration stopt during the act of swallowing? Must not the chink of the glottis be shut while the morsel is passing, and must not the diaphragm stop and relax to admit it to the stomach? How, then, are these actions to be associated, unless the exercised sensibility of the tongue, pharnyx, and œsophagus, be transmitted to the roots of nerves, which are to spread wide the influence to the organs of the motions subservient to respiration?

Even with regard to the sensibility of this nerve, the experimenter labours with disadvantage. Whilst there is here a circle of relations, as in the symmetrical nerves of the spine, it does not follow that the sensibility of the nerve is similar, or that, when injured, it shall present similar results. It may be sensible, and yet give no pain; not being like a nerve of the skin, appropriated to give pain and ring alarm.

* Atticus having a fistula, which he thought made him obnoxious to his friends, resolved to starve himself to death,—and did so. So Corœlius Rufus, pedum dolore correptus.—See *Pliny's Letters*.

It may be, and I believe is, finely sensible to the purpose for which its sensibility was bestowed; it may bring all the proper muscles to combine in their office, and yet the animal may not "howl" when the nerve is tied or crushed. By experiment, the heart has been declared insensible; whilst a deeper study of the subject informs us that it is alive to every impulse, to every motion of the body or passion of the mind. The muscles surrounding the eye will be more excited by the touch of a feather than by the pressure of the point of the finger. So it occurs that, although the sensibilities of the mucous coat of the pharynx and œsophagus are capable of ordering the finest combinations of the muscles, they refuse to be rudely questioned by means of the knife and point of the hook. In this we see the consequence of running away with part of a discovery. Had the experimenter been aware of the full effect of the circle of relations established through the nerves, he would have seen that the question was, whether the quality of the nerve was to carry the impulse inwards, and whether or not it was sensible. My original statement was to the effect, that the respiratory nerves were those "which connect the internal organs of respiration with the sensibilities of remote parts, and with the respiratory muscles;" that is to say, the internal nerves of the class, the *Par vagum* and *Glosso-pharyngeal nerve,* unite the sensibilities of the lungs

and stomach, with the larynx and pharynx; and these, with the muscles which move the chest, and combine the motions of the chest with those of the long-drawn air-tubes. Nor did I neglect to notice, "that we are to consider the stomach to be fully as much tied to the respiratory muscles as the lungs themselves," the act of vomiting being only a new combination of muscles under the irritation on the *Par vagum.*

In addition to this, I took much pains to show that the nerves of respiration have a centre and a source of motion independently of the brain above, and the spinal-marrow below: that as long as these nerves are connected at their roots, and the portion of the *medulla oblongata* from which they arise possesses life,—the act of breathing will continue. Further, that if the spinal-marrow be divided below the origin of the respiratory nerves, and also the *par vagum* on both sides of the neck, the action of respiration will continue. These are facts which have met with no attention, and yet which are worthy of the inquiries of the ingenious. On the investigation of this subject will depend the questions, How far the state of the lungs governs the act of breathing? how far the sensibility to that condition has influence? and, lastly, how far respiration is ordered by a centre of power independently of the lungs?

The peculiarity in the muscles governed by the res-

piratory nerves, is shown in their mode of action. If we irritate the heart after it has ceased to contract, we do not excite one act, as we should do in pricking a common muscle; but a succession of actions which continue for a certain time. So when an animal has ceased to respire, if we distend the lungs, an action peculiar to the class of parts is set up; not one effort or spasm, but a continued succession of respiratory motions, until the stimulating cause is exhausted. It would be difficult to explain this on the supposition that these are nerves endowed with no other properties than those of the regular spinal nerves, or that the centre from which the action emanated is the same with volition.

M. LONGET has written in so liberal a spirit, that I am particularly called on to quote and to animadvert on the passage in which he objects to the respiratory nerves. In pages 134–35 of his Experimental Researches, he objects to the system, because the *Glosso-pharyngeal* and *Par vagum* are sensible nerves and not muscular. My position was this: that there is a set of nerves having a common centre, having peculiar functions, not given to all creatures, but to those only breathing with a complex apparatus, and which retain their power, and minister to the respiratory motions, long after conscious sensation and volition are gone! that they are so far independent and *entire*;—that

they are capable of sensation in the limited sense;—that impressions are received and acted upon, independent of consciousness. I had not so disentangled these nerves, or rather their branches, as to designate which were motor and which were sensitive; but I taught, that, in both respects, as a system, they are entire and competent. I had also taught that the *par vagum* is the great nerve which communicates between the lungs and the motor branches, ordering and ruling the influence of these motor nerves, and consequently the act of respiration. I had also taught, that the sense which leads to the act of deglutition, is in the glosso-pharyngeal nerve; and I added, that the distribution of the fifth nerve shewed how taste and mastication were combined, and how the glosso-pharyngeal nerve combines the motion of the tongue and pharnyx with the imperative sense which demands the act of deglutition. Looking back on the days in which I publicly taught these things, I apprehend that I was not far from the truth.

How does the matter stand now? Every anatomical fact recently advanced, and every experiment made, tend to strengthen my original position, the more that they were not so intended. I saw that the plexus of these nerves, as they proceed in their course (for I looked upon their intricate connections as equivalent to a plexus), is for the purpose of combination, and

I imagined that it would be impossible to disentangle them according to their qualities or functions. I certainly did not then conceive it possible to institute those experiments on their roots which have confirmed the truth of the system in so extraordinary a manner. And now I must express my astonishment, that after those experiments, the fair and legitimate conclusions should be rejected! They amount to this,—that in *the class* so distinct in function, and exhibiting this distinction, by surviving all other symptoms of life, there are ganglionic nerves, and these nerves are *sensitive*; that there are other nerves which have no ganglions, and these are *muscular*. In what, then, consists the objection to my original position? I grant that I overlooked the ganglions on the *par vagum* and *glosso-pharyngeal* nerves; but I had furnished the means of detecting my error. We are indebted to those who have discovered the ganglions on these nerves; and by the facts ascertained in the one class of nerves, now made to bear on the other class, two important circumstances are brought to light: *first*, that it is universal that there are ganglions on the sensitive nerves; and, *secondly*, that the existence of these ganglions on the sensitive nerves of the respiratory system confirms the conclusions drawn from a less perfect survey of that system. The experiments of M. LONGET and of Dr REID give great interest to the enquiry. But I again say that I depend

on the anatomy. Now, anatomists who have been directed to a more accurate inspection of respiratory nerves, have discovered points of the utmost consequence to the establishment of this system. If we look to the anatomy, and then to the experiments, there is brought to bear such a combination of proofs that he must be incorrigible and cased in prejudice, who can refuse his assent to the distinction which I have made into two systems. My regret has been, that my views have been received in so bad a spirit that our youth have been misdirected; and, that in a subject which promised to have been all our own, we must now lean on foreign authorities. I allude to the ganglionic structure of this class of nerves, and to the experiments, which, combined with the anatomical facts, round and complete the proofs of the correctness of the opinion, that these nerves stand apart and form a system of sensibility and action independently.

There are posted up in the anatomical rooms of the University two proposals of subjects for investigation, as prizes. The first is for a prize to the best dissection of the Glosso-pharyngeal, the Par vagum, and Spinal accessory Nerve, specifying a comparison of the ganglionic swellings on these.

The second prize is offered to the dissector, who, by prosecuting the Diaphragmatic Nerve back to its origin, shall establish its relation or resemblance to the

accessory nerve. Much as I respect the real workers and contributors to our knowledge, I must see the confirmation of what is advanced by the inspection of the book of Nature itself. And sure enough our dissections should put those idle physiologists to shame, who, by speculative notions, and who without either dissection or experiment, have so long obstructed the reception of this system. SCARPA compared the *par vagum* (pneumo-gastrique) to the posterior root of the spinal nerves, and the accessory to the anterior root; but he knew not the important distinctions in these roots. BISCHOFF, by experiment, shewed that the nerves of the voice came not from the par vagum, but from the accessory nerve. M. LONGET more than confirmed this.

We find the anterior of this class of nerves, the Portio dura of the seventh, the great motor of the face, or of the nostril and lips, without a ganglion; the second, the Glosso-pharyngeal, with a ganglion.* The third, the Par vagum with a ganglion—the fourth, the Spinal accessory nerve, a muscular nerve, and without a ganglion.

And now turning to the experimenters, what correspondence do we find? 1. The Portio dura to be

* I have directed the student particularly to examine the ganglion of the Glosso-pharyngeal nerve, for if it be proved, as it appeared to me, to embrace a part of the nerve only, I shall not put implicit confidence in the experiments made on this nerve.

the muscular or motor nerve of the face. 2. The Glosso-pharyngeal to be the sensitive nerve of the tongue aud fauces. 3. The Par vagum to bestow sensibility in all its progress. 4. The Spinal accessory nerve to be the great muscular or motor nerve of the system, combining with the Diaphragmatic nerve!

These are surely most remarkable facts in confirmation of the system.

I have so repeatedly expressed myself against experiments, and turned from them in favour of anatomy and the study of functions and the experience of practice, that I cannot retract my opinion, and I must regret the many hundred cruel dissections of living animals by which the facts have been substantiated. I still hold the opinion, that, by pursuing the anatomy on the acknowledged fact, that sensitive nerves were distinguishable by ganglions, and motor nerves by their absence, the profession might have given their belief to the arrangement which I proposed—that these nerves stood distinguished by the peculiarity of their origin, course, intertexture, and final distribution. But we must not undervalue the importance and very extraordinary nature of the phenomena observed in experiments.

Bischoff and Longet have opened the heads of animals—have turned forwards the cerebellum, and have exposed those nerves, and have experimented on the

spinal accessory nerve and par vagum. I do not mean that they carried on their observations together, but they both ascertained the following very singular results.

They found that, dividing the roots of the spinal accessory nerve, the motion of the glottis, which dilates and contracts in breathing, was stopped. M. Longet, pursuing the experiment with galvanism, found, that, on exposing the glottis of a horse, and at the same time displaying the par vagum and spinal accessory within the vertebræ—he could, by applying the poles to the roots of the spinal accessory, cause motion in the corresponding side of the glottis. Again, on carefully guarding the roots of the spinal accessory from the galvanic influence, and putting the poles to the roots of the par vagum, no motion was produced.*

Now, I confess, if I had done this, I would have confidently said, "You perceive how accurate my conclusions from the anatomy have been." But my friend Dr Reid, on making similar experiments, draws opposite conclusions. For he says, "These experiments upon the glosso-pharyngeal aud spinal accessory nerve have furnished results in direct opposition to the respiratory system of Sir Charles Bell." I fear, like

* I suppose that the roots of the nerve were separated from the medulla oblongata, for otherwise, the circle being complete, the respiratory apparatus should have been moved.

many others, he has not consulted my original papers. I am at a loss to conceive what he expected.

Once more I return to my position and affirm, that this question must be determined by the anatomy and the study of functions. Wherever nerves take a devious course, or are knit together for a purpose which we do not see, there is some neglect on our part, some negligence in considering the uses of the organs. Here, for example, in the respiratory system, are two nerves, the recurrent of the par vagum and the spinal accessory; the one taking a retrograde course, and the other taking a strange origin and most circuitous course. Something, then, must be radically wrong, if our received opinions do not embrace a reason for these deviations from the common course of the nerves. Now, I have accounted for the first, the course of the recurrent, by shewing, that, through it, the muscular fibres of the trachea are connected with the motions of the glottis, as a necessary provision for expectoration, and without which, there would be no means, mechanical or otherwise, of guarding the passage to the lungs. With regard to the other, the spinal accessory nerve, a child may read the lesson. It is a muscular nerve, it has no interruption by ganglion: these experiments confirm it. It arises from the side of the spinal marrow, from the same part with the diaphragmatic. It mounts upwards, whilst the latter takes a direct course to the

diaphragm; mounting and entering the skull in a manner peculiar to itself, it joins the par vagum and glosso-pharyngeal nerve. It forms a plexus with them, and then they separate to their destinations. The accessory sends its branches to the pharynx and larynx; it turns down upon the neck and shoulder, to supply the great muscles which, in excited respiration, expand the chest. It goes to muscles which are already, and, by a direct course, plentifully supplied with nerves.* They say it is not a nerve of respiration, because it governs the tube by which the breath is drawn, a most singular deduction; it is not a respiratory nerve, because, after it is cut, the great muscles still move. Has it not been shewn that these muscles have a double office? Grant that this nerve being cut, these muscles of the neck and shoulder still move, what is the inference, the spinal accessory having been proved to be a muscular nerve, and nothing but a muscular nerve? What is the inference from this experiment,† if it be not that this nerve

* Scarpa Tabulæ Neurologicæ. Tab. I., 51, 53.

† The method of investigation by anatomy is adapted to elucidate both systems. The course of the spinal accessory, and the course of the recurrent nerve of the eighth pair, force us to investigate, and indicate what should be the line of enquiry. In the rooms of the University there is now open a dissection by Mr Spence, in which a fine fibre of the Par vagum is traced the whole length of the neck and parallel to the trunk: this filament comes directly from the spinal accessory. See the Author's observations on the

takes its peculiar origin, its singular and circuitous course and distribution, in order to combine the actions of the respiratory tube with those muscles that we see excited in every violent act of respiration, whether to clear these tubes of obstruction, or to perform the many accessory actions of the respiratory apparatus?

I must repeat, that it is impossible that those who oppose opinions so fairly deduced from the anatomy, and now confirmed by experiment, can have perused my original papers.

The respiratory nerves arise in a manner peculiar to themselves. They mingle together in their course, and freely exchange filaments. They diverge to all the parts, however remote, or otherwise unconnected, which combine in the act of inspiration. Injure these nerves at their root, and in the instant, all motions of breathing simultaneously stop; and so vital are they, that death instantly takes place without a sound ut-

transverse fibres of the trachea, *Phil. Trans. of London for* 1832. In like manner, the branch of the ophthalmic division of the fifth nerve passing into the skull instead of going out of it, like the other nerves, was like a point of interrogation, or a way-post to direct us; and when it was traced descending through the cribriform plate of the ethmoid bone, it implied that it was to give that sensibility to the Sneiderian membrane, which the olfactory nerve could not bestow. In like manner, the peculiar origin of the third nerve, of the sixth, and of the fourth, are all pregnant with curious matter. —*See the Author's papers in the Trans. of the R. Soc. of Edin.* vol. xiv. part 1.

tered, or a motion indicative of the change from life to death. On the other hand, their influence long survives sense and volition; and they are the last to die.* Notwithstanding all this, there are men ingenious and well-informed, who, by the original imperfection of their studies of anatomy, will confound these nerves with those of the regular spinal nerves,—those agents of sense and volition common to every animal, whether it breathes or not. If any thing further be necessary to distinguish these respiratory nerves from those of common sensibility and volition, it must be attained through the study of the apparatus of respiration, and the various inferior uses in which it is employed. It would no doubt be a pleasing task to study the means which nature employs in the lower animals which do not breathe by lungs, as substitutes for our organs of breathing. What wafts the air loaded with effluvia to the olfactory organ of the insect? What gives sound where there is no breath? But, taking the classes of animals which breathe by lungs, it is curious to observe how these nerves increase in complexity as the animal rises in the scale. It is no less curious to observe the occasions taken, if I may so imperfectly express myself, to use the stream of air in those which breathe, in its entrance or its exit from the lungs; by what

* Introduction to the Author's paper on the compound functions of the *Portio dura*.—*R. Soc. of Edin.* vol. xiv. part 1.

adaptation of moving parts the inspired air is drawn forcibly through a narrower aperture, and made to circulate over the nerve of smelling; by what means the expelled air is made to rush over the cordæ vocales, and to observe how the muscles of these cords are simultaneously in action with the act of expiration, so that the cords are prepared to vibrate and to produce sound; and how all the passages are in motion to produce due reverberation of these sounds, and all in unison.

All lesser functions must participate with those of the great function of respiration. If, for example, we take the ingenious and conclusive experiments which have been instituted to detect the different offices of the laryngeal and recurrent nerves, as agents in *vox et loquela*, we cannot mistake the nature of their intimate relation to the great apparatus of breathing.* How a different notion should be taken up, is the wonder.

Whether, in short, the stream of air which is drawn through the respiratory tubes, be brought to play on the organs of smelling, or driven in the opposite direction, to give voice and speech—or used in clearing and protecting the passages by coughing, expectoration, or sneezing,—these are *accessory functions* which have their main force in the apparatus which inhales

* See Longet sur les Nerfs et les Muscles du Larynx. Consult also the Author's paper on the Human Voice, in *Phil. Trans. of London.* Read Feb. 2. 1832.

or expels the breath. Mr Hunter said, no organ could be found to perform two offices without betraying imperfection. This idea was not expressed with his usual philosophical felicity; for what can be more admirable than the different offices performed in the mouth, pharynx, and larynx, or through the whole extent of these tubes, which are at once pneumatic and hydraulic, without interference or disturbance? What an admirable thing to see the adjustments of sensibilities and appetites, drawing into combination the requisite action of muscles, finely adjusted and suited to their object, never superfluous, guarding life and ministering to our wants even when reason is absent, and where no mandate of the will could produce the combination of such complicated actions.

Is it surprising that physiologists, experimenting among the complex system of nerves which minister to all these functions, and at a time when the bodies of the animals are laid open by dissection, and the blood, which gives life, is flowing from every pore; and when their sensibilities are so violated, and their finer sensations overpowered by pain—should fail in producing satisfactory results?

But there is another grand difficulty, and I must admire the intrepidity of those who stretch beyond what sober reason dictates—I mean the connection of mind with these organs of sensation and motion. It

is quite obvious, that, whether we contemplate the apparatus of voluntary action, or of this system of parts devoted to the respiratory action, the scheme, system, or apparatus, are complete in themselves: and that impressions are made and conveyed, so as to bring the machinery into operation independently of mind. But that, again, the mind has a controul over this machinery, and that the latter becomes an instrument under the will, there is no doubt. Here, then, is a distinct subject of inquiry, which, had I the power, I would desire to see kept distinct, so that subjects sufficiently difficult in themselves should not again be involved in inextricable confusion.

For my own part, I have been satisfied with small results : the origins of the nerves,—the columns from which they arise,—their possessing ganglions or wanting them, their connection and distribution, are all on which I have attempted to reason. I have been wading in shallow water, and have not struck out into the depths. In other words, the fibrous texture of the brain, the relation of the columns of the spinal marrow, I have not ventured upon, nor have I been able to frame a conjecture as to the influence of the mind and consciousness upon the bodily organs.

"The System of Respiratory Nerves" wants nothing but an expositor, and I rest confident that some one, with happier talents for explanation than I pos-

sess, will some day undertake the work, and put the objectors gently aside, so that they shall wish what they have said to be forgotten.

The practical views connected with the "Respiratory Nerves," the author must reserve for a future part of these essays.

ESSAY VI.

ON THE FORCES CIRCULATING THE BLOOD, AND THE DIFFERENCE OF THE MOTIONS OF FLUIDS IN LIVING AND IN DEAD VESSELS.

NOTHING is more easy of comprehension than the course of the circulation of the blood, as announced to the student; but when it is taken philosophically, the subject presents great difficulties.

When the viscid and coagulable nature of the blood is considered,—when we reflect, that apparently the whole solid mass of the animal body consists of vessels, through which this fluid is driven,—when we see thousands and thousands of capillary vessels intermediate between the extremities of arteries and veins, —when, in short, we attempt to estimate the extended surface of contact between the solids and fluids, and the force of attraction of the containing and contained parts, we perceive that there are difficulties in the subject which can only be removed by entering on a

new science—the study of those laws of the living frame which control the mere physical properties of fluids and solids.

If we agree with the opinion of those authors on physiology, whose works are most commonly in the hands of our medical youth,—that the heart is sufficient to the circulation—that a force in the centre drives the whole mass of blood—then the following difficulties present themselves.

The arteries which carry the blood out from the heart are of different lengths and curves; yet when an artery is accidentally divided in operation, if it be of equal caliber, the jet of the blood is equally strong, from whatever part of the body and limbs it is derived.

The organs of the general economy vary in their distance from the centre of the circulation, yet the force of circulation in them, and on which they depend for the performance of their functions, is not influenced by their greater or less distance from the heart. Or if these organs be occasionally excited, as they certainly are, in the revolutions of the animal economy, the blood is accelerated through them, without a general disturbance of the circulation.

Not only do organs assume different states of activity in the diurnal changes of the economy, but animals have their seasons in which certain of these parts are developed, and become more vascular; and, again,

that activity subsides—and this partial variation does not disturb the general circulation.

The circulation adapts itself to the position of the body, recumbent or erect. The arm which is raised has a different pulse in regard to strength from that which hangs by the side. Every organ, even a muscle, as well as the brain, during its activity, requires an accession of blood or an increase of the force of the circulation through it. An artizan, who holds with his left hand, and uses the hammer with the right, has the circulation increased in the right beyond the left; and, in time, the limb used, and all that side of the body, will increase in bulk and strength beyond the other.

Again, high action may be observed in the heart itself, without a corresponding activity or increase in the general circulation; the perspiration, secretion of urine, or any of the discharges, do not keep pace with the heart's activity.

That blush of redness which, on dissection, we see in organs which have been arrested in their function by death,* is not more conclusive than the blush during life, which suddenly spreads over the face and neck. Why should passion thus suffuse the cheek, unless it were intended for expression? and how could

* As, for example, in the jejunum, at a stated time after taking food, or the ovarium during menstruation.

it be produced without a partial change in the circulation ?*

These, and many other phenomena, are inconsistent with the hypothesis—that a force at the centre is sufficient for all the purposes of the economy. I shall, in the end, bring more distinct and practical instances, both of partial increase of action and of partial subsidence of action. It is with a view of explaining these cases that I enter on this enquiry. I shall divide the enquiry into two parts ; *first,* the *action of the arteries between the heart and capillaries ;* and, *secondly, the circulation* in the capillaries, and as exhibited by the microscope.

Of the Structure and Properties of the Artery.

On this subject I write with Mr HUNTER'S great work under my hand. Since his time, nothing has been done to controvert or weaken his propositions. When

* It is questioned whether this flush arises from an increased action of the arteries, or from a sudden change in the tone and capacity of the veins. It is, however, a very sufficient proof of the sudden and powerful influence of the nervous on the vascular system. The burning sensation implies activity of the arterial system, and that it is not a mere passive relaxation in the cutaneous veins.

we think of his genius for these enquiries, the great discoveries he made, opening to us a new science, it is surprising that his experiments on the arteries should have been so negligently considered. What a contrast do the labours of JOHN HUNTER offer to those of modern physiologists ! He had riches in his power, his income was great, but all was expended on objects of science ; and he left that splendid monument, in his Museum, which is unparalleled in Europe. It exhibits that industry and perseverance which ever accompany scientific genius. However much this Museum may draw attention by its extent and splendour, it is little understood ; for it is not a mere collection, there is a system throughout. Comparative anatomy is there cultivated as the foundation of *physiology*, and physiology as the foundation of *pathology*, which is the investigation of human morbid structure. The whole scheme or conception is noble as the execution is wonderful ; all is done with the aim of diminishing human suffering. Many objects *there* were obtained by painful efforts, pursued not without danger, and in scenes obnoxious to most men. We do injustice to make comparison of the Museum of JOHN HUNTER with the cabinet of the naturalist. It is one thing to pursue Nature over fields and gardens, and among rocks and mountains, and to make collections, whilst pleasure, health, and vigour of frame are at once obtained. It

is another thing to spend nights in the dissecting-room or the cellars of an hospital in the investigation of disease.

When we contemplate a mind like Mr HUNTER'S, exclusively directed to one great object, he dissecting and preparing with his own hands the minute structure of the animal body, his thoughts the while deeply engaged, and suggesting experiments on the living animal, to illustrate what he only obscurely saw in the dead, we may well wonder that they who treat of those subjects after him should overlook his labours, and prefer to follow authors who have yet to learn what is due to precision of statement, as well as a right mode of investigation. Dissection and experiment are the proper means of pursuing a subject like this; for, whilst the capable mind is kept steady to its object by the first, it is enriched by reflection. They who contrive to evade the facts and arguments adduced by HUNTER, and who indulge in abstract propositions and mistaken theories, deserve little favour with philosophers.

I proceed, in the first place, to consider the two properties of the coats of the artery, *elasticity* and *muscularity*. We cannot advance to this part of our subject by any better means than taking the statement of Mr HUNTER—that on making a transverse section of an artery, two distinct circles are seen, an outer one, dense and white, and an inner one, dark and fibrous. These

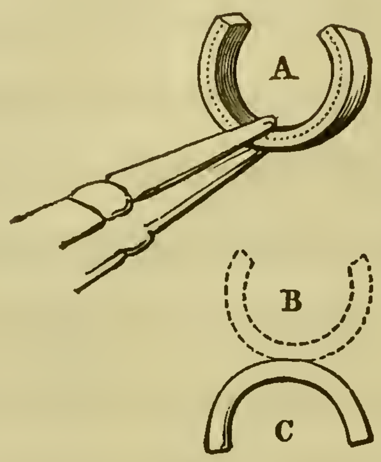
fibres encircle the artery, and do not run in the longitudinal direction.

The simplest demonstration is generally the best and most conclusive. Make a transverse section of the aorta, which is the great artery near the heart. Make another of the femoral or humeral artery. On comparing them, the exterior white circle is broad in the greater artery; while the dark circle is close upon the inner surface, and very narrow. The section of the lesser artery exhibits the two circles more distinctly; and the dark circle is broader, whilst the white one is relatively less. In the condition of these two circles, we have the measure of the living contractile power on the one hand, and the elastic property on the other.

My observations have been made on the living arteries of the human body, taking the opportunity of the amputated limb, the instant it was separated. In the amputated limb of one, who has suffered a grievous accident, being in health and strength, and more especially if he has lost much blood, the arteries are like whip-cords, by the firmness of their contraction. As on the face of the stump, so on the corresponding surface of the limb, they feel like cartilages.

On cutting off a portion of the artery, being still in possession of its living properties, and slitting it up, it springs open to a certain extent, but it retains its curve inwards. But if this portion be put in water

next day, it is everted and curled up in the opposite direction, thus,—



A represents the section of the artery slit up, but contracted by its living force. B, The same in outline. C, The condition of the section, when the living property has become exhausted, and the coats are contracted in an opposite direction by their elasticity.

Further, on taking off a long portion of the popliteal artery whilst it is a cylinder, it retains its straight form; but, on slitting it up in its length, it is immediately bent back, not transversely, but longitudinally.

Simple as these facts are, they are conclusive. Why is not the transverse section of the artery everted when first divided? or why only after a time? Is it not, that, whilst possessed of life, the inner circle prevails, and that when life is extinct, the outer circle prevails?

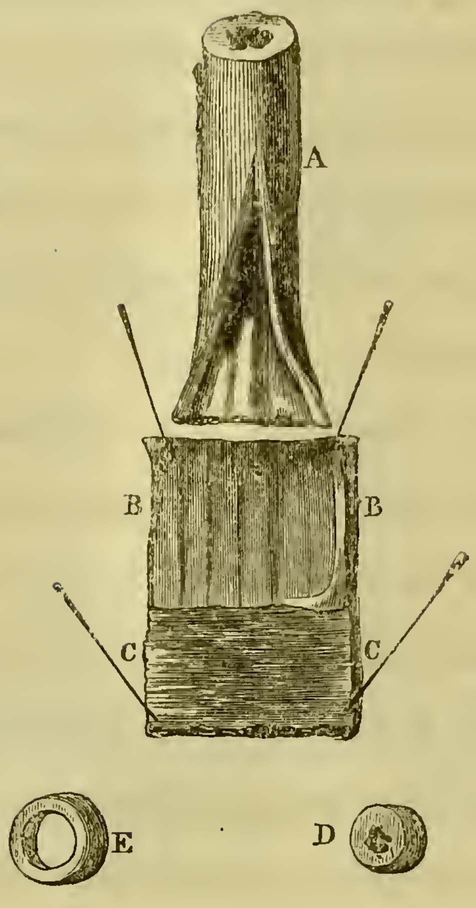
Again, a somewhat longer portion of the artery being slit in its length, it immediately curls up in its longitudinal direction. The explanation is obvious; in

the one case the circular fibres resist the elastic force because life continues; but as there are no longitudinal fibres possessed of living contractile power, in that direction, the elastic property of the exterior coats has immediate freedom to bend the still living artery in the longitudinal direction.

Now authors, such as the celebrated Professor Muller, confer the elastic property on the fibrous inner coat; at the same time denying its muscularity. But these simple experiments prove, that the dark fibrous coat has a property of resistance which belongs to life, and that property being lost with the life, the outer coat prevails, because the elasticity of that coat is a property common to living and dead matter.

Again, taking the popliteal artery from the amputated limb, and cutting off a portion of it, and then slitting up that portion, I stretched it transversely, and held it in the forceps, when I saw it gradually contract. It did not fly back to the cylindrical form as by elasticity, but slowly as by muscular contraction.

All the coats of an artery have a certain elasticity, the outer coat the most, and the fine inner coat the least. The defect of elasticity in the inner coat is shewn in the section of the living vessel, for it is thrown into folds, and these are longitudinal, being produced by the circular fibres.



A, The popliteal artery, recently cut from the amputated limb. BB, shews a portion of the artery with longitudinal rugæ. CC, The muscular fibres of the artery. D, An artery contracted by its living force. E, The same, having been dilated and left to contract by elasticity alone.

In the limb of a person who has lost blood previous to amputation, the contraction of the circular fibres is so strong, and these rugæ so prominent towards the interior, as nearly to close the artery. A pin-head will fill up the cavity of the popliteal artery.

Some distinguished names are ranged to enforce the opinion that the artery is not distended laterally. It is indeed difficult to measure the degree of lateral distension, but notwithstanding it is possible to prove it. I

took a portion of the artery and cut it up, so that it was exactly square. I appended weights to the margins, so as to stretch it in all directions, and *it was stretched equally in all directions by equal weights.* If the artery be equally elastic in all directions, we have only to remember, that an artery in the living body is always full of blood, and that the heart acts on a column of blood; it follows, that as fluids receiving an impulse, convey it equally in all directions, so the artery must be dilated both in its calibre and in its length.

The mistake on this subject has arisen from observations made on the trunks of arteries where the dilatation is very little. The greater arteries are as conduit-pipes; we shall prove that the extreme branches are agents.

The fibrous coat is weaker in the artery near the heart, and stronger relatively as the artery is remote from the heart. It would be difficult to account for this upon the supposition that the elasticity was the special property of the fibrous texture, since it would be accumulating resistance to the heart's action in proportion to that action being weak.

But the fibrous texture, possessing a vital contractility or muscular power, it accords, that it should be greater the more remote from the heart, being a power in aid of the heart. We must not lose sight of the

fact, that in the natural action of a muscle the relaxation coresponds with the contraction; an elastic power, or a tonic action in the arteries, would not contribute to the propulsion of the blood, the resistance being continual. There must be a property of relaxation or facility of dilatation in the arterial coats, without which there can be no power in the artery to come in aid of the heart. Many physiologists give to the circular fibres *tone* only; I think it must strike the reader that tone, as it is defined, is so much of the nature of elasticity, that it would be a property superfluous.

There are many facts demonstrative of the greater vital force of the smaller arteries over the larger, and Mr HUNTER'S observation must recall anatomists to the circumstance, that on injecting the arteries of an animal after being bled to death, the injection is delivered back into the trunks, by the smaller arteries prevailing over the greater; a circumstance which does not take place in the human body, because there, the properties of life in the individual parts, as well as in the combined whole, are extinct before the injection is made.

In the turtle, the muscular fibre is very distinct and very powerful. The arteries are like cords before injection, and under the force of the syringe they dilate at once and fully. The greater capacity and contraction of the artery is accounted for by the direction of

the contracting fibres; they are oblique and interwoven. When the viscera of the turtle are sent by the cook of the hotel, the arteries are found still to retain their vital contraction after many hours.

On making a section of the artery of a limb recently amputated, we have proof of the greater power of contraction of the branches. On cutting across the femoral artery, and cutting across the tibial artery, there is exhibited a striking difference. The larger artery is contracted to a certain degree, but the lesser artery to a much greater degree; it is almost closed by contraction. In the lesser artery, the inner coat is raised into rugæ, and these are longitudinal to the artery, and obviously owing to the contraction of the circular fibres.

After a certain time, on dilating these sections, they do not contract to their former state; the difference is remarkable, but chiefly in the section of the lesser artery. (See the fig. p. 40, D E). The explanation is—that when these arteries were cut across, they were in a state of vital contraction. They were contracted by two forces, the vital and elastic; but when the vital force was exhausted or extinct, the coats contracted by the mere physical elasticity. That the difference between the vital and elastic forces is greatest in the section of the smaller artery, goes to prove the increasing muscularity of the artery as it recedes from the heart.

Before attempting the explanation of the full action of the artery, and especially the important influence of its vital power, I shall make a comparison of the action of the muscular fibre, in combination with the different organs. And for this reason, that the difficulty of bringing arteries into action, by direct mechanical or chemical injury, has led many to deny their muscularity.

The Variety in the Time and Mode of Action of the Muscular Fibre in connection with the different Organizations.

The irritability of a muscle is the possession of a power of contraction, excitable by direct stimulus, exhausted by continuance, and requiring rest.

The tonicity of a muscle is that unwearied permanency of action which is maintained without the presence of stimuli.

These are sweeping inferences, but they will prove of little use in our inquiry.

I. A muscle of volition, as of the limbs, being irritated, acts directly and forcibly, and ceases. Certain muscles of this class are capable of two distinct modes of action ; they move under the direction of the will, or

they move in respiration in regular time, and during sleep or insensibility; they partake of two distinct influences, and of a great variety of combinations.

II. The muscular fibres which are around the hollow viscera, and which some distinguish by the term muscles of organic life, act very differently. They are accommodated to the function of the organ, and possess a peculiarity in the time and mode of their action. They are controlled by the sensibility of the part, and not through the will; their actions are sometimes called automatic.

III. On pinching the intestine of an animal knocked down and insensible, no immediate contraction is perceived. The experimenter might be led to turn away, and say that the intestine is insensible to injury. But after a little time, he perceives a vermicular motion slowly arising; one portion of gut is drawn in, and another evolved. Familiar as this action is, it is interesting, as exhibiting the fine adjustment of a certain property in the muscle to the function to which it is allied. The action does not cease as in the first instance, on withdrawing the stimulus, but continues, and is propagated downwards along the intestinal canal. Here, as touching our subject, let not the words of Mr Hunter be forgotten. " Whatever becomes a stimulus to one part of a muscular canal, where a succession of

actions is to take place, becomes a cause of relaxation to the part beyond."

IV. It is interesting to observe how the contractions vary in the course of the canal. The morsel, when, by voluntary action, it is pushed from the mouth into the pharynx, is there seized by a grasp as rapid as thought, though involuntary, and it is hurried by a rapid succession of action and relaxation into the stomach,—the relaxation still preceding the action.

V. The fibre, apparently of the same structure, forming the muscular coat of the stomach, is yet in most curious contrast with the muscular coat of the œsophagus. The contact of food with the latter causes an instantaneous and rapid action—received into the stomach, the ingesta excites no immediate activity, nor does it, until the process of digestion is proceeding or accomplished; then, with an appropriate action, it is urged from the left to the right extremity of the stomach, but by an action unlike what takes place either in the œsophagus above, or in the intestine below. Even in experimenting on the irritability of the œsophagus, the action is seen to be rapid in the tube, but when propagated onwards to the stomach, the fibre suddenly changes its mode and time of action.

The fine sensibility of the pylorus has ever been a subject of admiration. It opens its lips, and lets por-

tion after portion flow into the duodenum, and, guarding the intestine, it protects the life and health; rejects what is imperfect or offensive; throws it back by inverted action to undergo the process of digestion again, with a nauseating sensation; or, calling into co-operation other muscles, rejects it by vomiting.

VI. We may contrast the action of the muscular fibre of the stomach with that of the other hollow viscera. The bladder is in strong contrast—its actions are directed by a sensibility seated in a spot. It is pressure against that spot which controls the whole muscles, which must combine before a drop of urine can flow. It is by indirect means, by causing pressure through the action of the abdominal muscles on the fundus of the bladder that the sensible spot at the cervix is influenced, and that we command the action of the bladder; and when excited, the action of the bladder differs from that of all the other hollow viscera, being characterized by one continuous impulse.*

* Some observations on experiments will be found in the preceding Essay of this volume. We have even here the proof, that experimenters should study closely before they draw conclusions from the phenomena of living animals. In the case of fractured spine, the patient loses the power of expelling the urine, not from the lost sensibility of the bladder, but from the loss of power to make pressure with the abdominal muscles, and thereby to excite the sensible spot of the bladder.

VII. Of the hollow viscera, the muscular texture of the uterus offers the greatest deviation from the more familiar action of a muscle. During the nine months of gestation it is increasing in strength, the fibre being daily more developed. At the appointed time it acts, and the mode of action varies from all other examples. Were it the fulness and distention which excited the uterus to action, the time of delivery would be uncertain; but, independently of the contents, the period is appointed. For, in the case of extra-uterine conception, though the child and placenta be exterior to the cavity, and remote, the uterus is agitated, and contracts at the term of nine months, though there be no child to deliver.

VIII. The condition of the sphincters of these hollow muscles is as curiously adapted as the fibres of expulsion. When physiologists say they are dilated by the contents forced against them, they betray inattention to matters of experience and practical importance. The irritation of the intestine above, is the cause of relaxation in the anus, and the fertile source of disorder there. The os tincæ is relaxed before delivery, or the worst consequences befall the mother and child. The mistake has arisen from not observing in all cases the fine adjustment of the opponent muscles; of the *relaxing* to the *contracting* muscle.

In all these instances, we perceive the contractility of the muscular fibre suited to the function of the organ to which it is attached,—differing in time and mode of action—and variously induced to act. Some fibres act under the will, some by direct contact and irritation, some by remote sympathy, some by distention, some are arranged and brought into action by the susceptibility of a spot where sensibility is concentrated. —*See Circle of Nerves*, page 3.

IX. There is still another instance of motion where muscularity is denied—I mean the play of the iris in adjusting the pupil. Anatomy exposes, in this perforated curtain, two sets of fibres, the one forming a delicate sphincter on the inner margin, the other a set of fibres concentrating from the outer margin. That these two sets of fibres have motion, and are opponents, must be allowed. They are not moved by direct injury, but only by means of the degree of light striking on the retina, and therefore it is that their muscularity is denied.

Direct injury to these fibres, by the point of a needle, certainly does not induce action in them. The light concentrated by a lens, and made to fall on the iris, does not move the iris of the amaurotic eye; but if it fall on the other eye, being sound, the iris of the disordered

eye moves readily. This is only another instance of the fine adjustment of the power in the iris; for were it subject to be moved by any other cause than the state of sensation in the nerve of vision, it would not have proved a protection to the eye, but much the contrary. Some, to avoid a difficulty, have imagined that the iris is moved by a kind of erection through its vascular structure, by the injection of the blood into it. This hypothesis does not explain how fibres actually incorporated should be differently erected; nor does it correspond with the anatomical structure. Besides, I have seen the iris cut by the knife of the oculist, without contracting or subsiding, as must inevitably have taken place had it been extended by injection of blood. Nor does bleeding the eye by scarification produce the slightest change on the pupil, which surely would have followed, had the condition of the iris depended on the fulness of its bloodvessels.

Thus we approach our subject;—we have a fibrous texture with a finely adjusted action, whilst no direct injury effects a change upon it. If we now expect to perceive irritability in the muscular coat of the artery, we must study the cause and mode of its natural action. I know of no experiments where the natural relations have been preserved, the arteries distended by impulse, and the action of the heart made to precede that of the artery; yet these are necessary conditions.

Contemplating the artery as a very long tube, elastic in both directions—longitudinally and transversely,—remembering that it is full of blood, though not to the utmost of its capacity of distention—what shall be the effect of the discharge of the ventricle of the heart into it?

If the coats did not yield,—or were rigid tubes,—the impulse of the heart would be felt in the extremities in the instant. But, as the coats yield by elasticity, and recoil, the heart's action must be propagated in undulations; in other words, the dilatation cannot be synchronous in the whole arterial system: the dilatation of the nearer artery must precede in time that of the remote artery. Now, taking into calculation that the artery is muscular as well as elastic, the result is important. If we take the definition of muscularity, as opposed to elasticity; that it is a power which reacts with a force greater than that which excites it, then must the successive dilatations and contractions of the artery accumulate an accelerating movement to the extreme vessels.

Let us apply this reasoning to a familiar experiment which has made a strong, but a false, impression. When one leg is thrown over the other, the foot rises and pulsates at every stroke of the heart. Not only is the foot moved, but if a weight be hung upon the toe, the pulsation will be more distinct. The common explan-

ation of this is, that the curve or angle of the Popliteal artery behind the knee, is thrown straight by the impulse of the heart. If the force of the heart did really reach the artery at this angle with a power to throw it into the straight line, and, at the same time, to lift the leg and foot, and the weight upon it; calculating also the distance of the weight from the centre of motion in the knee-joint, and the nearness to that centre of the impulse upon the artery; what a power we must allow to the heart!

The facts here have been entirely mistaken: it is not the extension of the popliteal artery which produces the motion of the foot. If we contrive to hang the leg, and support it by the bones of the knee-joint, without making pressure on the muscles of the calf, there is no pulsation of the foot, although the angle, or bend of the artery behind the knee, be greater than before. It is when the weight of the leg rests upon the mass of muscle that the pulsation takes place. It is the united action of the numerous small arteries in the fleshy mass which makes the pulsations, not the trunk of the artery. It is not only in the leg that this pulsation may be observed, but whenever we rest on a fleshy mass. If in bed we rest the cheek on the biceps of the arm, we shall be sensible of the same pulsation. I shall show the importance of this in the diagnosis of disease.

In the mean time it announces a fact,—that the branches of an artery have more power than the trunk from which they are derived.

To explain this phenomenon, we have first to observe, that the artery, on receiving the impulse from the heart, does not dilate at once in all its length; but that it is dilated near the heart before it is dilated remote from the heart. In other words, undulations take place. Presuming on the muscularity of the artery, and that the action of muscularity is characterized by relaxation and reaction, what will be the effect when the artery is thus dilated and contracted in successive portions of its length?

Tonicity being a certain uniform prevailing contraction, would amount to no more than elasticity. Elasticity contracts no more than to its state before it was extended. It distributes the force of the heart, but cannot add to it. Tonicity would do no more. But admitting that the fibrous texture of the artery is muscular, then each portion of the artery which is dilated, contracts both by elasticity and by muscular action, and thus the first dilated portion throws the blood forwards into the second with a pressure greater than it received from the heart, and so, the longer the artery the greater its power. At the centre, the greater the power of the heart; and remote from the centre, the greater the power of the artery.

The wave on the surface of water in a canal, has been taken as an illustration of the undulation passing through an elastic tube. If we take all the circumstances into account, the illustration may be admitted to explain the condition of the living artery. On the more sheltered side of the water there is a ripple, a little further on there is a wave, further still, the waves rise into a higher undulation: But they, who offer this instance, leave out the permanent influence of the wind, which, though blowing equally on the surface of the water, has a greater influence on the wave, which rises higher, as it exposes a larger surface to play upon, so that there is a continually increasing power of the wind. It is the same with the muscular power of the artery. Comparatively, the dilatation of the smaller arteries is greater than that of the larger, and so comparatively is the muscular action.

We perceive how this argument touches the *tortuosity of arteries.* The subject has much interest. When I pointed to the circumstance, that the arteries towards their termination became tortuous [which may be seen in any well injected part], and that this is especially manifest in the arteries of glands; it was said that "this was to retard the blood, and to give time for secretion."

A tortuous artery, as seen in the natural body, has two consequences; when the artery is unexcited, and

nearer to the condition of a dead tube, it will retard the blood; but when the vital property of the artery is excited, then it has unusual power. The practical remarks which follow this paper, give sufficient proof that a tortuous artery is not an inactive one. We can have no hesitation in concluding, that the nearer an artery approaches its destination, the more it is under the influence of that part or organ: and, carrying with us the acknowledged nature of excited muscular action, that it consists of more free dilatation, as well as more forcible contraction, we perceive that the artery is suited to all the necessities of the circulation.

1. That the powers moving the blood are capable of accommodating the circulation through an organ according to its distance from the heart.

2. That with the excited exercise of an organ, there is a proportioned increase in the flow of blood.

3. That a gland in the natural course of the economy, pouring out its secretions, is provided with an additional flow of blood.

4. That in every instance of excited action, the source of power being in the blood, there is an increase in the circulation of the part, without necessarily disturbing the general system.

In short, that there is a power of accommodation in the extreme vessels, whilst the heart retains a uniform action.

I need not add, that when a general excitement is called for, by a more universal activity of the frame, means are provided, which, however, make no part of our present enquiry.

CASES AND SURGICAL REMARKS IN ILLUSTRATION OF THIS FIRST PART OF THE ESSAY ON THE FORCES CIRCULATING THE BLOOD.

In the preceding Essay, we see how the contraction of the artery and its influence in corrugating the inner coat, diminishes the stream of blood; and as this contraction is greatest in health and vigour, so it happens, that in amputations in the case of sudden accident, or on the field,—the main artery, or at most one or two branches, require the ligature; whereas, on the face of the stump of patients reduced by hectic from scrofulous caries, or some similar cause, three arteries for one in the former case require to be secured.

Of the great questions of surgical practice, there are none more difficult to solve than those which arise from pulsating tumours. A tumour, for example, which is embraced by the gastrocnemius and soleus muscles, receives a pulsation from the muscular arteries, in addition to those which compose its substance, and there is danger of mistaking it for aneurism.

At a very early period I dissected a tumour of this kind.* It was characterized by a congeries of veins externally, and a tumour surrounded with tortuous veins has always tortuous arteries in it. In its composition, also, was that soft anomalous substance since called medullary and brain-like. This tumour was seated under the gastrocnemius muscle and behind the knee-joint. It had an obscure pulsation, and burst out in bleeding. These circumstances gave rise to the belief that it was an aneurism. Amongst many different opinions, the better informed, on consultation, prevailed, and declared for amputation, by which, in those young days, the limb came into my hands.

From similar cases occurring in my hospital practice, I have often had to reflect on that first case. With the same external characters, and with the same brain-like substance within, they have occasionally differed in this, that some only have had pulsation. This, I beg my reader to understand, may depend on the activity of the tortuous arteries in the composition of the tumour, but principally on its situation, tightly embraced by the bellies of muscles. Surgeons are aware of the pulsation given to tumours, by the contact of the larger trunks of arteries, but are not so

* The same which I exhibit at Lecture.

much alive to the effect of the smaller tortuous arteries.*

Mistakes do, in fact, occur in the most dexterous hands. Can any thing shew this better than the mistakes of the best surgeons abroad and at home? Sir Astley Cooper assisted Mr Guthrie in the operation on the iliac artery, when the case was found to be a tumour, not an aneurism. My present colleague cut down, on the common iliac artery, with the concurrence of consultants, for a pulsating medullary tumour of the groin. Mr Nicol of Inverness tied the subclavian artery for what seemed an aneurism, but was not. Dupuytren tied the femoral artery for such a pulsating tumour.

Tumours on the Head.

I cannot resist being drawn aside, to illustrate my subject by the instance of tumours growing on the

* Medical Communications, vol. xi., p. 95., a pulsating tumour in the leg, supposed to be aneurismal. Similar tumours are described by Pott, Pearson, Scarpa, Pellatan, Dupuytren, Boyer. These are fungous tumours, which engage and open the veins. But the circumstance which throws obscurity is the pulsation when they are engaged with the gastrocnemius and soleus muscles.

head. On returning to Edinburgh, after 31 years passed in London, I regained my first case-book, written under the inspection of my brother, and among other cases the following :—

This gentleman is 25 years of age. It is seven years since he first observed a tumour on the right eyebrow. It was then not much larger than a pea. His medical attendant ordered purgatives, never doubting that it would dissipate. But it began to pulsate, and enlarged to the size of a nut, and became discoloured. A sensible surgeon proposed to cut it out, but the patient leant to other advice, which was, that it might be let alone with impunity. It was supposed to arise from a tight hat, and that it would subside. This statement refers to a period of six years ago. Among a variety of opinions, he was advised to compress it with a plate of lead. The attempt gave him great pain; continuing to increase, it was operated upon nine months ago. An incision was made towards the temple, and the artery was there tied. Another incision was made higher, and another artery tied there; still the pulsation continued. It was thought necessary to cut into the tumour, and this was deemed effectual; but a fortnight after, the patient felt the pulsation as strong as before.

The tumour is inflamed on its surface, a livid redness pervading it. The pulsation is very strong. The

artery runs in a serpentine course towards it. If he takes spirits or wine, it is suddenly perceived to change; when handled it is excited.

On this tumour Mr John Bell operated, taking the whole away by dissection.

Our early impressions are the strongest; and after experience has ever a reference to our first cases. I have seen many tumours similar to this. There came into the hospital a man with a beating tumour on the back of the head; the artery which nourished it had been tied, but without diminishing the tumour or pulsation. I have forgotten under what mismanagement this man died, but, on injecting the vessels of the head, the occipital artery was seen to be of very unusual size, and tortuous in its course to the tumour. I was in consultation with Sir Astley Cooper on a tumour of the face, when we joined in opinion that tying the carotid would avail nothing. When I mentioned a particular case as the ground of the prevalent opinion, that tying the nourishing artery affected the coating of the tumour, he said, "That goes for nothing; I have the tumour in a bottle; the man died."

Those tumours which take the appearance of aneurism do not grow as an aneurism does: the artery is *excited by the tumour*; and as long as it keeps alive, it will draw nourishment from anastomosing arteries, and

the arteries so excited, will take the tortuous or serpentine course.

M. Brechet, after enumerating the many cases of fungous tumours which are recorded in the collections of England and France, concludes from his experience, that the tumours which arise from the meditullium of bones, have often an aneurismal origin, and that in these cases the tying of the artery is effectual in removing the tumour. He must, I think, have been seduced into this conclusion by some singular case of success, and I think his further experience will lead that distinguished pathologist to a different conclusion. —*See the paper quoted above.*

I may here observe, that if a vascular tumour has sprung from a bone, and is partially encased in walls of bone, these walls resisting, will throw the pulsation forcibly to the exposed and prominent part, just as the dura mater pulsates in the trepanned holes of the skull.

It is in vain that some reasoners will object to my conclusion, and affirm that the tortuous artery is for retarding the circulation, and that the slowness with which the blood flows through it, is the means of supplying more nourishment! Can any ingenuous person feel the strong pulsation of these tortuous and enlarged arteries, branches of the temporal or occipital artery,

when supplying a tumour, and maintain that the blood is retarded in them? Let him witness the impetuosity with which the blood flies from such a tumour as I have described, when cut into, and he will not continue in the opinion, that tortuosity in the living vessel retards the flow of blood, although a curved leaden tube retards the flow of water.

I have stated that the artery is not unconnected, but dependent on the part or organ to which it tends.

In hæmorrhage, even accidentally produced, the flow of blood is under the influence of the portion of the frame to which it belongs, with which it is sympathetically joined. I remember being set as a pupil, to compress a bleeding vessel, of small size, on the back of the hand. After sitting long with my finger pressing a bit of lint into the wound, I desisted, and carefully withdrew my finger. Having sat by the patient for some time, he was roused from sleep by a pain in the hand, and soon after the blood burst out. I again adjusted the compress, and continued the pressure a long time; and now the night being far advanced, and the position irksome, I once more withdrew the finger, and I had an hour of rest. But, again, the pain shot through the hand, the precursor of another bursting out of blood. And this happened so often that I learned from the patient's sensation when

the arteries were about to pulsate and the blood to flow.

There is a property in the living frame to restore the blood, which a part or a limb has lost,—a power of reparation. It is under this law that hæmorrhage is propagated, for there appears plainly a power of equal distribution; a defect is felt, and an action set up to restore the balance. This touches the practice of frequent bleeding, as from the head; there is certainly a disposition engendered to make blood and to direct it to the part thus habitually drained.

Some writers have mistaken, or rather have neglected to mark the distinction of tying an artery on the face of a stump after amputation of the limb, as contrasted with the tying of an artery in aneurism. Mr John Bell and Mr Abernethy conceived that the happier result of tying the artery on the stump, was in consequence of the artery shrinking, and burying itself in the cellular membrane. This is certainly important in every operation; but the grand distinction is, that in amputation you take off the stimulus which the presence of the limb gives to the circulation. Whereas, in aneurism, the nisus to action comes from the limb, and the pulsation in the trunk does not cease until the supply by collateral arteries is established—after which the trunk has comparative repose.

Example of the Doctrine in the Case of Varicose Aneurism.

When, by the infliction of a wound, which penetrates both vein and artery; when, by a singular combination of circumstances, a permanent passage is made between the vessels, a remarkable phenomenon presents itself, in consequence of the blood flowing into the vein with the force of unsubdued arterial pulsation. This condition is called a *Varicose Aneurism.*

The most extraordinary example of this aneurism I saw in Rome, in the collection left by the celebrated FLAJANI, in the *Arcispedali di S. Spirito.* A stiletto had been struck, so as to enter a little anterior to the spinous process of the ilium, and had passed through the external iliac vein into the artery. That the sufferer had survived the wound is a remarkable circumstance; but it must have arisen from this,—that the blood of the artery had ready entrance into the vein, by which the impetus of the blood, which would otherwise have torn up the cellular membrane, and made a common aneurism, or suddenly have caused death by hæmorrhage, was taken off in this new direction. The artery *continued to bleed, but the blood was received into the system* instead of flowing to the ground!

This circumstance affords an interesting proof of the effect of hæmorrhage upon an artery.* I obtained from the Fathers the privilege of making a drawing of this preparation. The external iliac artery is large and tortuous down to the point of communication; below this it is small. The veins of the whole member are enlarged to an extraordinary degree, so that a congeries or chain of veins extends over the whole limb from the ilium to the great toe.

Notwithstanding the error committed in the following case, I have not omitted, on all proper occasions, to detail it. A gentleman came to town [London], exhibiting to me a varicose aneurism in his arm. The annexed engraving, Plate I. fig. 1., will best convey an idea of its appearance. The swelling rose over the median basilic vein, having the cicatrix left by the wound of the lancet, in its centre; it had all the characters described by Dr HUNTER. It was soft and compressible, the blood could be pressed out of it, without leaving

* In the same city of Rome, and not far from the Hospital of the S. Spirito, in the Church of St Augustin, there is a famous statue of the Virgin. Around the column adjoining the statue there are seven belts, and in each belt there are stuck ten stilettos and ugly sharp knives! Whether these knives had done their work, and had been given up in despair and remorse, I could not learn. But it is a natural reflection to make, that many, many wounds may have been made without the stiletto penetrating through the vein into the artery.

any stool or hardness. On putting a cord round the fore-arm, the swelling of the varix did not diminish. On pressing out the blood from the sac, and placing the finger on the point of communication between the vein and artery, the sac of the dilated vein remained empty: on raising the finger and putting the ear to the arm, that peculiar whizzing sound could be heard which accompanies the flow of blood from the artery into the vein. In short, it was a distinct case of varicose aneurism from bleeding in the median basilic vein.

Much against the patient's desire, I refused to do any thing. I recommended that he should use no bandage or support, but only avoid powerful action with the arm. Some months elapsed before I saw this respectable gentleman again. He had lived in great uneasiness of mind, and in perpetual apprehension of the swelling bursting, when it was probable he should have no assistance. He had returned from a distance, and resolved to have an operation performed.

At this time there were certainly appearances and sensations to give alarm, for, besides the pulsation and discoloration of the swelling in the bend of the arm, the artery from the armpit to the bend of the arm was of most unusual size, tortuous in a remarkable degree, and with sudden turns, apparently just under the skin, and pulsating strongly.

I entertained the idea, that, by opening the skin over

the bulging twist of the artery above the tumour, I could, by a very simple operation, put a ligature upon it, and so far diminish the impulse of the blood into the dilated vein, as to remove all apprehension of its bursting, and give a circuitous direction to the blood. Before condemning it, my reader will perhaps think of the effects to be produced by this operation. I do not think he will anticipate the unhappy consequences. By an incision, three quarters of an inch in length obliquely across the artery, I put a ligature around it. This had no effect on the dilated vein; the pulsation in it continued. Certain that I had put the ligature on the artery, I now conceived that there must be a high bifurcation: a few touches of the knife disclosed the other division, and I put a ligature round it. As soon as I drew the ligature, the pulsation ceased in the vein, and the swelling subsided. On this I undid the ligature which I had applied on the other artery; the vein immediately swelled, and the pulsation in it returned; I therefore drew this ligature also, and then tied both arteries. I need not aver that the parts were very little disturbed.

I was alarmed on observing that the hand and arm became immediately very pale, and that not only the swelling was flattened, but that the veins did not rise. Presently the nails became livid, and the hand cold. In short, from that moment ortification commenced;

next day the system sympathised with the condition of the limb; a low delirium succeeded, and the patient was lost.

Looking back, it is easy to give a reason for this unhappy result of an operation so very simple, and it has its importance in reference to the pathology of aneurism. I am called to attend to this circumstance before bringing the case in illustration of my main subject.

The ligatures put on the two divisions of the humeral artery, every one will admit, amounted to no more than would have taken place from the tying of the trunk, had there been the usual distribution of the artery. When the trunk of an artery is tied, the branches above the ligature work into the branches below; and these, by retrograde action, pour their blood into the main artery below the ligature, and the artery acts because it is distended. But, in the present case, there being a hole of communication by which the blood had easy egress from the artery, it was not sufficiently distended to receive the impetus to action. Whatever power was possessed by the arteries below the ligature, carried the blood not forwards in the course of the circulation, but direct into the vein. Consequently the circulation was deficient in the hand and fore-arm, and hence the disastrous consequences.

I come now to the examination of the arm. The

two arteries resulting from the high bifurcation of the humeral artery were each longer than the humeral artery, when seen in its natural and common distribution. The branch which ran more superficially to form the radial artery was that punctured by the lancet. An aneurismal sac was formed in direct relation to the wounded artery; it adhered to the fascia; and with the fascia, to the great bag of the median basilic vein. Between the aneurismal sac and the vein, a hole of communication existed. Plate I., fig. 3.

The practical deduction from this case is, to enforce the rule, that the varicose aneurism should be let alone: That if an operation is to be performed, it should be, as in the cases of common aneurism, where the artery is to be tied above and below the wound made by the lancet. It was remarkable, that tying the branch which was wounded, had no more effect on the distended vein than tying the other branch which was not wounded. This demonstrates the perfect freedom of inosculation between the radial and ulnar branches.

The most remarkable feature in these cases is the character of the artery above the wound, that is, between it and the heart. If we compare the circumstances with the effect of a hole made in a tube conveying water, we shall be convinced as to the effect of the excitement of the living property in the animal body. If the leather pipe of a fire-engine be trod

upon, so that a hole is made in its side, by the escape of the water there, the jet from the mouth of the pipe immediately falls. But when the living artery is opened on the side, and the blood escapes, there comes a power into operation—the influence of the hand and fore-arm on the trunk of the artery which conveys blood to them. There is here a proof, that the parts beyond have an influence upon the artery; for, instead of contracting, as would inevitably follow in a dead tube, the artery enlarges to more than double its caliber, and becomes at the same time remarkably tortuous. The reasoning of Dr HUNTER is excellent on this head.* "Whence is it that the artery is enlarged all the way down the arm? I am of opinion that it is somehow the consequence of the blood passing so readily from the artery into the vein again. In the living body, an artery will as certainly become larger, when the resistance is taken off, as it will become smaller when it is compressed, or as it will shrink and become a solid cord, when the blood is not allowed to pass through it at all." But in this, and in the further illustration which this eminent authority offers, of the effect on the trunk of an artery of the growth of a wen, there is something wanting. In my mind, it

* Dr WILLIAM HUNTER first described this *peculiar aneurism.* —*Med. Obser. and Enquiries*, vol. ii. p. 408.

is the neglect of the principle, that the part to which an artery is sent has an influence on that artery, or, in other words, that the action and actual growth of an artery are influenced by the condition of the member to which it is sent.

The natural growth of a part, or of a limb, up to the period of its maturity, is attended with an excitement of its vessels. When it has ceased to grow, the arterial action subsides; but if a wen or tumour form in the part, as on the head, that morbid growth imparts a renewed stimulus back upon the supplying arteries, and we perceive the temporal and carotid arteries to enlarge and become tortuous, and their muscular power is increased, and their pulsation inordinate.

But if a part is cut off, the very contrary result follows. In the stump, after amputation, the arteries diminish, and the impulse against the ligature which secures them becomes more and more feeble.

In aqueducts and pipes, dilatations as well as contractions tend to impede the velocity of the fluid; for there is a loss of force attendant on every change of velocity. Dr YOUNG says, " A similar circumstance occurs in the animal economy. When an artery is dilated, so as to form an aneurism, it has been observed that the artery is usually distended above the cavity; and this effect is easily understood from the actual in-

crease of resistance which the aneurism produces, united perhaps with the previous debility of the artery."*

With all respect to this eminent man, his reasoning is misapplied. An aneurism generally takes place in an aneurismal or dilated artery. But mere resistance will not cause the dilatation of an artery; were it so, we should find the arteries of the stump after amputation dilated, whereas the contrary holds. In the varicose aneurism, there is no obstruction of the artery, and yet we perceive the consequence of its peculiar condition to be a remarkable increase of its activity, with a gradual increase in its caliber and its length. In the case of varicose aneurism, which I have noticed, in the S. Spirito at Rome, the artery is singularly enlarged and tortuous above the communication with the vein. But in the limb where the artery has been tied for popliteal or inguinal aneurism, we find no such enlargement of the trunk, although the collateral arteries are enlarged; for the caliber of the trunk of the artery will be in proportion to the call which the limb makes upon it, and no more. I observed no such enlargement of the trunk of the artery in dissecting the arm, in which the brachial artery had been tied for common aneurism from bleeding, as we see to be the

* Dr Young's Natural Philosophy, vol. i. p. 299.

case in varicose aneurism; and in the Col. of Surgeons, 1225, xxv. F., where the arteries of the thigh and leg have been injected after the operation for aneurism had been performed, we see no enlargement of the trunk above the ligature, but the reverse.

In the varicose aneurism the call to action is incessant, because the blood is drawn off by the hole in the artery, and to answer this call the trunk enlarges.

The varicose aneurism illustrates what takes place in *hæmorrhage*. We perceive that, in this case, there is a continual bleeding from the wounded artery, without that blood being lost to the system. It is a continual draining of blood from the limb, attended with a call upon the artery of supply to support the limb, and the effect we see to be a remarkable increase of the activity and power of the artery. Undoubtedly the same must take place in hæmorrhage, when the blood is lost, but the time does not permit us to see the effect. Must not habitual bleeding from a vessel increase its activity? How does this affect the question of periodical or frequent bleeding, to subdue what is called a tendency of blood?

Aneurism from bleeding in the Arm. Mistake as to Varicose Aneurism.

I present here a case from my earliest note-book. I begin to think that these early cases, taken when I observed keenly, and stated all I heard upon them, are of more consequence to a student than those of later occurrence, when many features, no longer new, are apt to be left out of our notice. "Walter Scott, a gardener, 25 years of age. Six weeks ago, he was bled by a cow-herd. He has been in the habit of being let blood, and he felt this time that the lancet went too deep. His arm was very firmly bound up. The pain was great, and stretched all up his arm. For a month nothing particular occurred, though still he had pain, when one day, after hard labour, the swelling increased suddenly. He was enjoined quiet, and not to work, and it remained stationary.

"But on coming to town (Edinburgh), and professional people handling it, as he says, roughly, the swelling has again suddenly increased, so that in three days it has assumed its present appearance.

"The swelling has a broad, flat base, and occupies the upper part of the fore-arm, and extends very little upon the biceps. It is circumscribed on the outside by the supinator longus, and it and the extensor carpi radialis

are raised up. The wound made by the lancet must have been large, as there is a scar, bounded by two prominent lips; the swelling enlarges daily, and is becoming of a darker colour. The pulse is distinct at the wrist.

" In these circumstances, without a vein being visible, it is singular that some of the gentlemen in consultation have expressed an opinion that it is a varicose aneurism, or that it was a varicose aneurism, and that now it has burst and become a common aneurism. This, I find, they rest on the circumstance, that, when the man came first to town, they could compress the tumour, and almost make it disappear; certainly this cannot be done now.

" *Operation.*—An incision was drawn quite over the tumour, and in its whole length. The fascia rose, of a dark colour, with bright tendinous lines, and like a regular sac. The fascia was punctured, and the finger being put into the wound, the sac was slit up, and out rolled an abundance of coagula. This being cleared away, the artery was visible in the bottom of the cavity, and the lancet wound in it was large and irregular, and obliquely across the artery.

" Some of the gentlemen present still maintained, at this stage of the operation, that they saw the confirmation of their opinion, that this had been a varicose

aneurism. They were deceived by the manner in which the loose sac presented, not slit up to the top, but lying collapsed and livid, and which they took to be the dilated vein. Of this, my familiarity with the anatomy left not a doubt in my mind.

"However, there lay the artery with a gaping wound, and it was necessary to tie it. The first ligature was put above the wound (nearer the heart); the blood flowed in a gush from below; a ligature was put below, and a third ligature was tied, by way of being very secure."

The patient recovered the use of his arm.

Remarks.—The mistake of some of the surgeons in consultation on this case, in fact arose from not having seen a case of varicose aneurism, and trusting to the description, that it was a character of that aneurism that "the swelling was compressible." The swelling of a common aneurism is compressible, before the coagulum becomes condensed. It is not probable that the blood is pressed into the artery, but rather that it is pressed into the cellular membrane not yet condensed, as it afterwards is.

I may add here, that the varicose aneurism presents essential shades of difference. The case may be a connection formed between the median basilic vein and the radial branch of the high bifurcation, or it may

be a communication, through the fascia, with the humeral artery in its more usual distribution. In the last case the veins are more distended, and are more enlarged above and below. There is another variety: there may be a complication of simple aneurism with varicose aneurism, that is to say, a sac may be formed around the wounded artery before the blood has made free passage into the vein. *See* Plate I., fig. 1. and 3. Mr JOHN BELL misconceived the matter when speculating on Mr PARK of Liverpool's case; he imagined that the deeper sac was a dilatation of one of the venæ comites.

There are two methods of operating for the common aneurism; one as performed in the above case, *only omitting the 3d ligature*, the other, by tying the humeral artery above the elbow, without opening the aneurism. This I have found effectual, while in other instances it has failed. The late Mr CHEVALIER was the first who operated by placing a ligature above the tumour, and I assisted him; it succeeded, though I said it would fail. The next operation did fail. Here (in Edinburgh) the operation has failed, and our surgeons prefer cutting through the tumour, and down upon the artery, and tying it above and below the wound.

The first incision should be made with some caution, since it is possible that there may be a high bifurca-

tion, in which case the radial artery runs close on the fascia, and is sometimes entangled in it. The ligatures should both be laid under the artery before the upper one be tied.

ESSAY VII.

ON THE FORCES CIRCULATING THE BLOOD, AS CONTRASTED WITH THE LAWS OF HYDRAULICS, OR THE MOTION OF FLUIDS IN PIPES.

SECOND PART.

In the first part of this paper, I hope it was demonstrated, that, to equalize the circulation of the blood, and to give equal quantities to organs differently situated, and at unequal distances from the heart, a principle of life must be embraced in our reasoning.

I may once more state, that the length and curve of tubes sensibly affect the velocity of fluids passing through them. If a long and a short tube be employed to empty a reservoir, though they be of equal diameters, and inserted at equal heights, the retardation arising from friction is so considerable as to cause a great difference in the quantity discharged in a given time. The quantity received from the longer tube will be less than that from the shorter.

If a tube be exposed to compression of its sides, by the elasticity or weight of the substance through which it passes, the resistance to the passage of the fluid through the tube will be greater the longer the tube; and if the tube be tortuous, it will be subjected to greater lateral pressure than if it were straight.

Whenever a pipe is bent, there is a loss of force, according to the degree of flexure and to the velocity of the fluid.

If a pipe of one inch in diameter, and another of two inches diameter, be discharging the contents of a reservoir, the larger pipe will deliver five times as much as the smaller, although only twice the diameter.

If, then, we consider the condition of the bloodvessels of an animal body, that they are of different lengths, curves, and caliber, not only carrying the fluids through an elastic mass, but that mass subject to great variety of pressure from muscular action, there must be an accommodating power in the bloodvessels to overcome these obstructions, and to equalize the velocity of circulation.

Although it be granted to the reasoning in the first part of this paper, that the arteries possess a property of increasing their dilatation as well as their contraction, by which the flow of blood is equalized, and the action of the artery accommodated to the distance of the part to which it is destined,—still a great difficulty oc-

curs in accounting for the free circulation through that incalculable extent of capillary vessels which constitute so large a part of the animal body.

When we consider the composition of the animal body, consisting of solids and fluids—whether the fluids be contained in cells, or between plates of membrane, or in capillary vessels—the attraction of the fluid and solid must be very great, unless influenced by other laws than those which govern inanimate matter.

The properties inherent in living matter are not easily conceived, being so different from those qualities of the living body with which we are familiar. The first series of facts which opened my mind to the distinct qualities of life in the animal body, was on viewing the different kinds and degrees of sensibility in the organs. It appeared that sensibility is not a common quality, nor pain a mere excess of sensibility; but that the different organs, and indeed the surfaces, possess sensibility allied to the particular impressions to be made upon them, and suited to the functions which belonged to them.

It may lead to the right conception of the nature of that property which resides in the inner surface of the bloodvessels, to contemplate the living influence in the simple membrane. The membranes not only retain fluid in a manner altogether different from a web or texture of the densest tissue, but also colour and odour,

whilst life continues in them. With the cessation of life the coloured fluids are imbibed, and percolate. The surgeon, in his operations on the living body, handles the intestines without the taint which attends the dissection of the dead. The bile which percolates and stains the viscera of the dead body, is retained without such transfusion in the living. This, then, is an example of repulsion or retention. There is no more curious instance of repulsion and attraction possessed by a surface than that in the mucous coat of the intestines. In the jejunum of an animal killed after being fed, the chyle will be found adhering to the inner surface of the intestine, in what appears a jelly, whilst the mucus and grosser contents are urged on in their course,—an instance at once of selection, attraction, and repulsion, whilst a principle of life is bestowed on the matter thus coagulated and adhering.*

Perhaps the most interesting discovery of the present day is the property of mucous membranes to urge on their secretions in a given course towards the emunctuary which is to give them exit. I allude to the ciliary action on mucous membranes; motions visible, even when a portion of the membrane is separated and placed in the field of the microscope.

Looking to a property of life in tubes or vessels,

* *Coagulation* being a quality of living matter.

the subject may be illustrated by the following fact, which I think conclusive. When a horse is bled to death, as the force of the circulation diminishes by the loss of blood, he breaks out into a profuse sweat. In such an instance it cannot be the force of circulation that impels the fluid, but something of the nature of that repulsion which permits the pores to throw off the watery portion of the blood.

By such considerations of the surprising properties of the living surfaces, we can more easily credit what belongs to the inner coat of the bloodvessel—that property of resisting or repelling the attraction of the blood, and also of retaining the blood in a fluid state whilst the life is uninjured or undisturbed. Mr Hunter's experiments shewed that neither heat nor cold, nor exposure to the atmosphere, nor stagnation of the blood, caused the coagulation of the blood. The fact which he noticed, and which every surgeon who has applied the torniquet to the limb, might have authenticated, viz., that blood, stagnant within its proper vessels, did not coagulate, has ever appeared to me the most interesting fact in physiology. Now, there is another fact which I had early noticed and recorded, that an injury to a vessel, or the disturbance of its living properties, has the effect of coagulating the blood within it; that the blood not only coagulates but is attracted to the interior of the vessel; that the coagu-

lation and attraction to the interior of the vessel are coincident. These apparently contradictory facts are explained by the consideration, that whilst life is entire in the vessel, the blood is preserved fluid, and there is no attraction to the surfaces; but when that property of life is disturbed or annihilated, the blood coagulates and adheres to the coats of the vessel.

When very young, assisting in my brother's operations, I observed that when I took hold of a bleeding artery with the forceps and bruised it, it ceased to throw out blood, and that the blood coagulated in the mouth of the vessel.

Pursuing the subject, I observed, that when the blood was collected in any of the cavities of the body, though there was life, yet that property of life had no power of retaining the blood fluid; that it coagulated as readily in the cavity of the abdomen or thorax as when poured into a cup. It was no less obvious, that when blood escaped into the common cellular membrane, it instantly coagulated: in short, that the property of retaining the blood fluid was in the interior coat of the artery, and in no other part; for although the texture into which the blood is extravasated is alive, yet it has not this property of life.

I had the pleasure of forming a close intimacy with the late Dr Curry of Guy's Hospital, and found him enterprising, philosophical, and eloquent. He exhi-

bited his very interesting experiments on the circulation in frogs many times in my house. He instituted these in illustration of his opinion on inflammation, in which it was his purpose to shew, that, on irritating the web in the frog's foot, congestion and *remora* took place in the veins, and that attraction took place between the globules of the blood and the distended veins.

I took this occasion of illustrating my opinions, which so far happily coincided with his. Whilst the membrane, between the toes of the frog, was extended under the microscope, I passed my lancet from below and divided the vessel. Although the globules were passing quickly, they were immediately arrested. None passed the divided end, none flowed from the opening. The globules were accumulated within the mouth of the vessel. I could see the impulse of the heart upon them; but at each motion forward, they were again drawn back as by an elastic force.

This idea of attraction and repulsion, although countenanced by modern discoveries with the microscope, has not been suggested by them, but has resulted altogether from what is observable in surgical practice. The motions in fluids, independent of the contractions of the solids,—the circular motions of the globules of milky fluid contained in the cells, both of vegetables and the Sertularia and Tubularia, and others of the lower animals, give us, in the present day, further in-

stances of a vital property producing attraction and repulsion, and the motion of fluids, independently of muscular action. They give countenance to my statement, that there is a vital influence exercised by the living vessel on the blood,—an influence which may be lost by disturbance of the coats, when the blood will assume the condition in which we see it out of the body. But to return, what takes place on dividing the vessel in the field of the microscope, is a miniature representation of what we see in the largest vessels of the human body.

The surgeon in his practice is familiar with this. If an artery be opened with the lancet, or by a fragment of glass, or, in short, by means which but little disturb the vitality of the coats, it will bleed the person to death if not secured by ligature ; and this will take place in so small an artery as that of the wrist: Whereas the largest artery, such as the trunk at the shoulder, if rudely torn, as by machinery or a cannon ball, does not bleed at all.

Surely a circumstance so striking and so essential to the right practice of surgery, should be deeply considered, and the rationale understood.

Sometime in the year 1810, I was a visitor of a club of gentlemen in London, the bond of whose union was, that they had studied in Edinburgh. Those were gentlemen since distinguished in their profession. In con-

versation with COOPER, TRAVERS, and BATEMAN, on hæmorrhage, I expressed my opinion, when I was met by this remark, that the distinction of a torn and a cut artery depended on a mechanical cause; that when the artery was violently torn, as by the separation of a limb by machinery, the inner coat was lacerated, and turned up within the vessel so as to oppose a valvular obstruction to the escape of the blood. This was to me a new idea; and as it stood opposed to my belief of the real cause of the difference, before sleeping that night I went into the dissecting-room to ascertain the correctness of the statement. I found it a mere fancy, for, on rudely tearing up the arteries, there was no visible obstruction from the state of the inner coat.

This subject touches the torsion of the arteries. This is a term given to a practice recommended in the present day. On the face of a stump, after amputation, the surgeon is to take hold of the end of the vessel and to twist it round—in number of twists or turns proportioned to the size of the artery. This amounts to no more than what I have been teaching for the greater part of my life: That if you take the forceps, and squeeze, twitch, or twist the mouth of a bleeding vessel, during an operation, it will cease to bleed, though the mouth stands gaping!

The use of styptics furnishes another illustration of the influence of the coat of an artery on the blood.

Astringents are used, but any thing which stimulates powerfully, being applied to the mouth of a bleeding vessel, stops the flow of blood. Styptics have been supposed to operate directly on the blood, which they certainly do; but they also act on the coats of the artery, and through them, on the blood contained within the artery.

In aneurism, we perceive the influence of the interior surface of the artery on the blood. At a certain period of life, the inner coat of the artery becomes friable and loses its elasticity. The inner coat chips or cracks, and the blood escapes into the interstices of the other coats—there it quickly coagulates; for the quality of life, by which the blood is preserved fluid, is not in the artery generally, but in the inner surface; so that when the blood exudes into the interstices of the coats, it there coagulates as in the common cellular membrane. How important this is, is easily conceived; for were it not so, there would be no temporary consolidation of the ruptured artery, but, on the contrary, immediate hæmorrhage and sudden death.

I may be permitted to conclude, that the laws of hydraulics, though illustrative, are not strictly applicable to the explanation of the circulation of the blood, nor to the actions of the living frame. Although we perceive admirable mechanism in the heart, and in the adjustment of the tubes, on hydraulic principles; and

although the arteries and veins have form, caliber, and curves, suited to the conveyance of fluid, according to our knowledge of hydraulic engines; yet the laws of life, or of physiology, are essential to the explanation of the circulation of the blood. And this conclusion we draw, not only from the extent and minuteness of the vessels, but also from the peculiar nature of the blood itself. Life is in both, and a mutual influence prevails.

PRACTICAL REMARKS IN ADDITION TO THE SECOND PART OF THE ESSAY ON THE FORCES CIRCULATING THE BLOOD.

First, with regard to the tortion of the artery, the matter has been misunderstood, from neglect of the just principles. The difference of bruising the mouth of a bleeding artery, and twisting it, is, that by the latter process the injury is done to a greater length of the vessel so twisted. If the tortion or twisting, screws round the coats, so as to injure them for the extent of an inch, or say two inches, the coagulum will be in extent proportionable. But the practice is dangerous, for should the artery recover, and should inflammation and the throwing out of coagulable lymph not follow the injury, then the clot of blood, after a time, is loosened from the inner surface of the artery, and it is brushed off by the force of the circulation.

If further proof were required of an important living property exercised by the arteries, we have it in the high vascularity of the coats—the profusion of the *vasa vasorum* ; since there is not a surer sign of the quality of life enjoyed by a part, than its high vascularity. My colleague, the other day, on tying the femoral artery, turned to the pupils and made an apology for the time taken (and never was an excuse less necessary), saying, that by this careful manner of proceeding, laying bare the artery without disturbing the parts, he had nine times tied the femoral artery, without accident or failure, by a simple ligature. How long is it since Mr John Bell gave that advice, and what disastrous ingenuity has been exercised since?

The history of the ligature of arteries exhibits a lamentable neglect of just principles. First, we find a succession of ligatures put on an artery to make security doubly sure—the introduction of wood and leather between the ligature and the coats of the artery—inventions to flatten the artery—the use of gold wire as a ligature—the use of animal substance in order that it might be absorbed—operations invented to prevent the coats of the artery being cut, and again to make sure that they shall be cut. These are so many proofs how easy it is to propagate mechanical notions in place of such as are drawn from the laws of the living frame. After ages of superfluous invention, the rule stands

simple and in few words : make no large dissection—disturb the parts as little as possible—see that the ligature is in contact with the proper coats of the artery—do not cut the vasa vasorum on which the union and final obstruction of the artery depends—and success follows, *if the patient be in health.*

There remains a subject of much importance, in which I could wish the ingenious members of the profession to interest themselves. I allude to the *spontaneous cessation of arterial action.* I drawfrom my journal this note.—" Here is a young woman who complains of weakness in her arm. It is not shrunk, it is not paralytic ; she has feeling and all the finer motions of her fingers. There is no rheumatic affection of the muscles : the defect is in the action of the arteries. She has no perceptible pulse from the wrist to the axilla ; and when I compress the arm above the elbow, the veins rise slowly and imperfectly." The opinion entertained in such a case is, that the trunk of the artery is pressed upon or interrupted by a clot. But this does not satisfy me ; for, in that case, why do not the symptoms correspond with those of aneurism, or the effect produced by tying the artery ? When the artery is tied, the collateral vessels take upon them the office of the trunk, and they are felt pulsating strongly. In a short time the circulation is perfectly

restored, and there is no weakness in the limb, nor difference in the turgidity of the veins.

I am impressed with the belief that the nervous influence upon the arteries is very different from that which ministers to motion and sensation. The latter we see cut off in palsy whilst the circulation is unimpaired; the former we see diminished where there is no defect of motion and sensation. Another case, much more common, I conceive to be connected with this enquiry; I mean the sudden interruption to the growth or development of a limb. We find, that, from a certain period of childhood, a part of the frame, generally an extremity, ceases to keep pace with the growth of the body; it remains a small appendage. The commencement of this extraordinary difference of development is not marked by any symptom or phenomenon in the economy. But in the end, we see the limb of a child joined to the proportions of an adult, although there is neither defect of sensibility nor of motion in the member, proportioned to its size. It thus appears that the stimulus or nisus to growth is withdrawn, without anything resembling paralysis. Is it not an affection of the vascular system, independently of sensation and volition?

When we perceive the circulation of a limb depending on the state of the limb, and independent of sensation and muscular activity; when we see hæmorrhage

burst out under this secret excitement, we do not see why that property, which is at one time increased and modified, should not on other occasions be defective or withdrawn.

I must confess my belief to be, that these changes, without the accompaniment of more obvious defects of sensation and motion, are dependent on the sympathetic system: For why should this system of nerves extend into the extremities, seeing that it neither ministers to sensation nor motion, unless to join them with the general system, and to order their circulation in conformity with that of the general economy?

These affections of the extremities, as far as I have been able to observe, are referable to disorder of the bowels; and the obscurity results from the very peculiar effects,—effects which cannot be noted but by the coming on of time, and the opportunity of comparison. The College of Surgeons have done me the honour of hanging a drawing of a shrunk arm in their Museum. I made that drawing to illustrate this subject. The gentleman had the whole axillary plexus cut across, so that all nerves, however distinct in function, were divided, and we see the consequences. He came to me to have his arm removed, and this because it stuck out before him, without sensibility or motion, and stiff by inaction, and nearly anchylosed in the joints, and shrunk to a third part of the size of the other arm.

In this we see not only the effect of the privation of all source of motion and sensation, but also of the stimulus to growth; the controlling influence over the vascular system. The arm is alive, yet cut off from the influence which should govern its vascular condition. It is in remarkable contrast with the state of a paralytic limb—which results from an injury to the motor and sensitive nerves in the brain. In that case, those nerves which maintain the relations with the sympathetic system, and which enter into the plexus of the axilla, remain undisturbed.

I shall state two cases that may be considered as touching this subject, and which are in contrast with each other. They shew the difficulties which encumber the inquiry.

My friend Dr Russell desired me to visit a man who was threatened with mortification of his leg, being, as he asserted, in perfect health. This person had travelled from Glasgow on the top of the coach; and in the middle of the night he was seized with sudden pain and spasm in the calf of the leg. The Doctor saw at once that the symptoms were anomalous, and on the succeeding day he took me with him. I found a man beyond the middle period of life: He was still in great pain, and what was more remarkable, the arteries of the limb were without pulsation. I could not feel pulsation from the groin to the foot. The

limb was at the same time pale, and cold, and benumbed. The toes were livid, and discoloration was commencing on the leg. The veins still rose, on putting a tape round the thigh, but slowly and imperfectly.

On a second visit, sphacelus had perceptibly begun in the leg. I could now feel pulsation in the collateral vessels round the knee, whilst at the same time I could not feel pulsation in the femoral artery. These appearances were, in some respects, analogous to those which attend popliteal aneurism, when the case is going wrong after operation. At this stage I was under the necessity of leaving town. In the mean time, a consultation was called on the propriety of amputation. The operation was performed, and the man sunk.

The dissection of the limb was highly interesting. There was an aneurism in the popliteal cavity. It was small, and the sac was full of coagulum, so that it appeared that the circulation through the trunk had been interrupted. The aneurism was peculiar, in as far as, instead of a rupture of the artery, and an aneurismal sac (formed of the cellular substance), on the most careful inspection, it appeared to be a dilatation of the proper coats of the artery.

The inspection of the limb was considered as "perfectly satisfactory." Still to me there was some obscurity—for why should it have presented a contrast

with the spontaneous cure of aneurism, and with the condition after operation for aneurism?

The last instance which has fallen under my observation of spontaneous cure of the popliteal aneurism occurred during the last season. In visiting the Hospital, my attention was drawn by my colleague to an interesting case. The note in my journal runs thus: "May 29, 1839. I received a note, three days ago, calling me to consultation on a case of popliteal aneurism, with a view to the operation. I could not attend; but coming to-day, I found the surgeons very naturally interested in the case, owing to the remarkable change which has taken place in the character of the tumour. I have carefully examined the man's knee. He is a weaver. He walked to the hospital. When received into the house the aneurism pulsated strongly. To-day I find the pulsation of the femoral artery natural, or rather stronger than usual. The tumour in the ham is hard, and without pulsation. I could believe there was room for deception, if I did not feel the collateral arteries round the knee enlarged and very active. I entertain no doubt on the case; it is an instance of spontaneous cure of popliteal aneurism."

In what consists the difference in these two cases? And why should the obstruction in the one case be attended with so little disturbance, and in the other with mortification of the limb? Nor do we see the reason

why, in the common case of popliteal aneurism, in which the operation having been performed, and the sac of the aneurism consequently obstructed by coagulum (which is the effect of the operation), there should not occur mortification, if, in the first case, the spontaneous mortification is to be attributed to the obstruction in the sac.

After the operation for popliteal aneurism, mortification does certainly sometimes occur; but then it has been preceded by tumefaction and consequent compression of the collateral arteries. Nothing of the kind presented in the case of the spontaneous mortification of the limb; there was no tumefaction to suppress the free action of the collateral arteries. To say that mortification took place because the trunk was obstructed, is equivalent to saying, that if you obstruct the trunk mortification will take place. I infer, therefore, that as obstruction to the trunk of the artery of a limb, by ligature, even with the addition of an incision, does not cause mortification, in the above instance, there must have been another cause, and, in all probability, that cause was a weakness of the circulation which preceded and occasioned the obstruction of the aneurismal tumour.

On the whole, I deem the case to be a farther instance of a debility of action falling on the arteries of a limb.

Plate II. fig. 1. is illustrative of the subject, as shewing how slight an impediment to the flow of blood will produce coagulation and obstruction in the aneurismal sac.

Vascularity of the Artery.

I have drawn a conclusion from the vascularity of the coats of the artery, which I trust the reader will not think without reason,—that the high vascularity implies a high vital function. When a limb is minutely injected, and a coarse injection of a different colour is thrown in, so as to fill the trunks, the *vasa vasorum* are then finely exhibited.

The following note shews that the artery is subject to the same fatal inflammation with the vein. I was called into consultation with my colleagues, and my note stands thus: "I find a man sixty-six years of age —the right arm pale and discoloured—the extremities of his thumb and fingers dark, and the hand and wrist slightly œdematous, and cold as marble;—no pulsation at the wrist to be felt, nor at the bend of the arm, and very obscurely towards the axilla.

"His voice is gone. I asked when; and he said, At the same time that he hurt his arm. His account was this:—In turning a key in a rusty lock, he used

his utmost force, and he thinks he bruised the ball of his thumb (the muscular part).

"I have seen this man again. The extremities of the thumb and fingers are mortified; the discoloration has ascended half way up the fore-arm. The veins of the fore-arm can still be raised by pressure above. In consultation, the opinion prevails that there is inflammation of the artery, that it creeps gradually along the interior of the artery. Some of the consultants think, that there is a rupture of the inner coat somewhere above. I give in to the first, but reject the second suggestion, for I see no cause for the chipping of the inner coat. The majority of consultants are for amputation, and for taking off the arm at the shoulder-joint. I object, on account of the severity of the operation, at the shoulder-joint, on an old man, who speaks in a husky whisper. Their argument is this—The disease being inflammation of the artery, if the arm be separated at the insertion of the deltoid muscle, we shall cut across the inflamed artery, and leave the inflammation to make progress. "My opinion is, that if the inflammation be still progressive, nothing will prevent its progress. At the time we first saw the case, the artery had ceased to pulsate two hands'-breadth above the elbow. How far has it now proceeded?

"When the limb was taken off [at the shoulder] I examined the mouth of the artery in the arm, and it had

a clot in it. I squeezed out some liquid blood, but it might be from the coagulum. The axillary artery did not bleed during the operation. The branches did freely: —a branch just above where the artery was cut across, bled, and it and the trunk were taken up together. " In the dissected arm there is a remarkable appearance. The humeral artery is inflamed through all its extent. The inner coat is of a lively red colour; the coats are reddish, transparent, and obviously inflamed. The radial artery is inflamed and filled with a clot. Near the division of the humeral into the ulnar and radial arteries, there is pus. The ulnar artery, down to its arch, is distended with a dark coagulum. " The man died on the third day from the operation. The lungs were diseased."

I do not notice the case to argue the question of amputation, or, if proper in the case, whether it might have been done lower down or not. I state it, to mark the liability of the artery to inflame, and the distinction between the symptoms in inflammation of the artery and those which attend inflammation of the vein. Further experience may shew the distinction to be owing to the course of the blood through them, *i. e.* to or from the heart.

But here is another proof that inflammation in the coats of the artery is attended with a cessation of pulsation, with the coagulation of the blood within it; and

with the attraction of the coagulum to the interior of the artery; the end being mortification.

The whole case excites surprise that the ligature of the artery does not oftener prove fatal, by inflammation spreading retrograde on the trunk.

ESSAY VIII.

THE DISEASES OF THE SPINE—DISTINGUISHING THE FORMIDABLE DISEASES FROM SIMPLE DISTORTION.

At the close of this view of the Diseases of the Spine, I have appended very valuable Notes by Mr Alexander Shaw. I have been long desirous that he should publish on this subject, in continuation of the work of his late brother. I am happy that my paper has drawn these observations from him. Mr Shaw was my pupil and assistant, and succeeded me in the Middlesex Hospital.

Something has become necessary as a guide in this department, and this will be apparent when we consider the formidable nature of some of the diseases of the spine, and how often they are mistaken. The cruel operation of cutting across the muscles of the back for distortion of the spine, gives proof of the ignorance which prevails. I know not, indeed, if such operations be more severe than the very common error of unnecessarily confining young ladies to the horizontal position for months, and I am well entitled to say, for years, under the idea of a caries of the spine, when

there is no such disease, for by this treatment their constitution is permanently destroyed.

The spine is, in every respect, a subject of interest. It is the keel on which the whole framework of the body is raised. On it depends the arrangement of bones, muscles, and nerves, so that the naturalist has properly taken it, as distinguishing the great class of the superior animals; a different disposition of parts, and a change of the economy of the animal, being the consequence of its absence. It is this which gives importance to the diseases of the spine, since their effects must be extensive in a part so essential to life, and so intimately united with the whole frame. In its mechanism nothing can be imagined more worthy of admiration. But the bones, cartilages, and ligaments which enter into its composition, are exposed to that kind of constitutional debility which is frequent in these northern climates.

The authority which all educated surgeons consider paramount, has well said, That the due exercise of the animal body is necessary to the perfection of its structure; and never was the apophthegm better illustrated than in the human spine. The exercise of the body is essential to the perfect condition of the spine. Hence the unhappy consequences of that practice which the surgeon is apt to think the safest, and as relieving him from responsibility,—ordering the patient to be laid supine, and to be retained so for months.

Although the spinal marrow, the most vital organ of all, be more guarded than any other part,—than even the brain itself, though deeper seated and surrounded with a stronger wall,—yet injuries do reach it; and it is its condition which gives such superior importance to the diseases of the spine. There are four sources of injury to the spinal marrow; first, from violence; secondly, from the curves and torsion of the spine; thirdly, from constitutional debility, or scrofulous action; and, fourthly, from deficient exercise and play to these pliant parts.

As errors in practice arise from the surgeon's education not embracing the whole subject, I shall enumerate the serious diseases, which are liable to be confounded with cases of simple distortion unaccompanied with disease and independent of accident.

The subjects which are to be considered by the medical consultant when brought to decide upon the condition of the spine, are these: 1*st*, Uterine disturbance, attended with fixed pain in the back; 2*d*, Disease of the spinal marrow itself, giving rise to debility in the extremities; 3*d*, Injuries of the spinal column in their remote consequences; 4*th*, Scrofulous caries; 5*th*, Distortion from rickets or mollities; 6*th*, Distortion from original malformation of the chest; 7*th*, From the effects of inflammation in the cavity of the chest contracting one side; 8*th*, Diseases of the hip and lower

extremity, producing a change in the direction of the spine. All these considerations come under review, in determining the condition of the spine, even in the more common case called lateral curvature. The mere enumeration of these diseases, embracing so large a portion of the field of practice, and requiring so thorough a knowledge, evinces the danger of permitting the practice, in distortion of the spine, to drop into the hands of the mechanic.

In making observations on these, I shall commence with what is generally the most prominent, and occupies the mind of the patient's friends—the injuries to the spine.

In the case of fracture of the spine, the consequences are, for the most part, so formidable and distinct, that the surgeon may not be aware that very great injury, even fracture of the spine, may occur without symptoms. Fracture may take place without the crushing of the spinal marrow, and consequently without the signs attributed to the accident. My notes of cases record several instances of fracture without immediate symptoms, yet terminating in paralysis, and in some finally by death. We could hardly believe, without such assurance, that a man, merely by sudden exertion to save himself from falling, should fracture the vertebræ; yet I have found it so on dissection.* But as

* In a late case with Dr Abercromby and Mr Joseph Bell.

this accident is apt to take place in the still firmer frame of the horse,—as his struggle, when thrown for castration, may break the spine,—we perceive how the accident may occur in the sudden exertions of a muscular man in saving himself when his horse slips up.

Although the bone will generally break before the cartilaginous and ligamentous ties of the vertebræ give way, still on these, there may be an injury hardly less to be lamented. In violent twists of the spine, though there should not occur actual laceration or diastasis, yet the ligaments are sprained; and just as we trace a disease of the ankle-joint or knee to a twist or sprain, so it happens in the spine. We are often told by parents that the projecting spine was a consequence of a careless nurse letting the child fall, when it is much more probable that the injury has been caused by the fretful child throwing itself violently back when in the nurse's arms.

Caries of the spine, whether arising from scrofulous diathesis, or from injury, is a formidable disease, and must always raise a question of interest in consultation on the distortion of the spine.—*See Additional Notes*, No. I.

Something will be inferred from the obvious constitutional peculiarities. There is pain in the part; the flesh of the thigh is soft and woolly to the feeling; the patient is easily fatigued, and feels pain in walking.

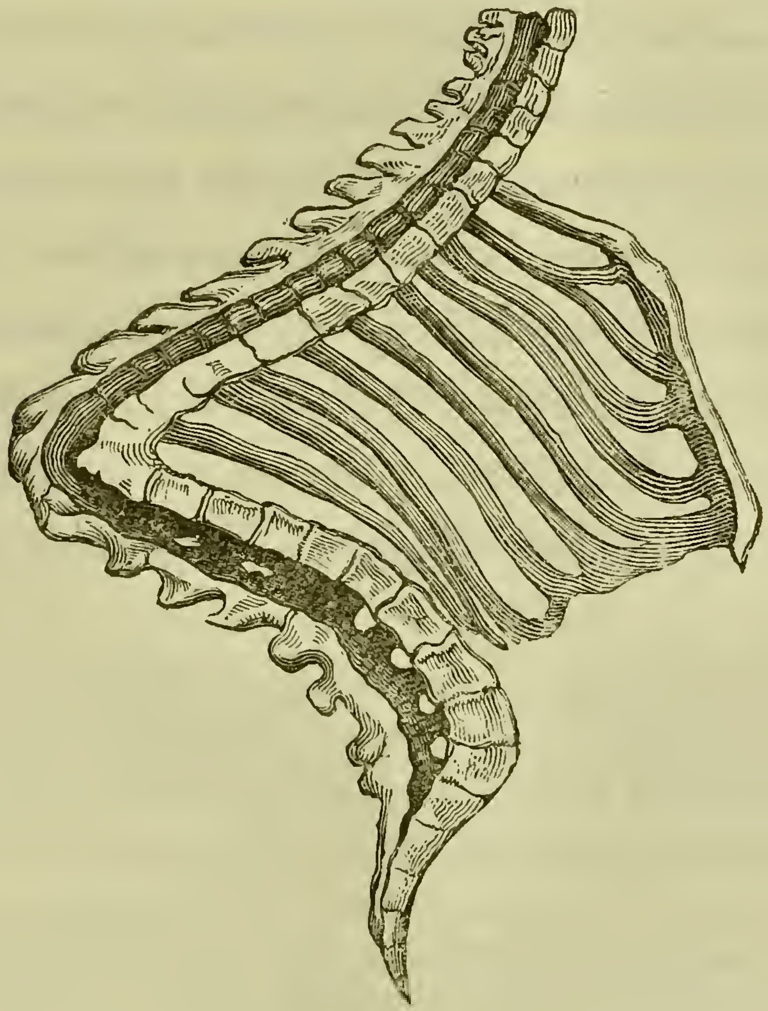
The toes are not accurately directed, and he stumbles; he is subject to spasm in the night: then comes more obvious paralysis, motion being more defective than sensibility. I give my attendance at present to two individuals, in both of whom the sense of touch is exquisite, amounting to torture when rudely touched, and this whilst the motion is lost. In both cases the inflammation is in the vertebræ of the neck, and it is the arms which are powerless.*

When the bodies of the dorsal or lumbar vertebræ soften under the inflammation and the incumbent pressure, and the bony matter is absorbed, and the column sinks; when we see the young person exhausted with pain and hectic, and, if permitted to walk, grasping his knees firmly to support himself, then substituting

* For the explanation, see the author's papers in the Phil. Trans. of London.

But these papers have been so long before me, that I am enabled to say that one of the cases, under the judicious care of Dr A. Robertson, has come to a happy termination. The gentleman had inflammation of the vertebræ of the neck, with a mass of thickened integuments over them. His arms were powerless, but the extremities of his fingers so exquisitely sensible that the slightest touch was torture. That morbid sensibility has vanished, and, at the same time, the motion of the arms has returned. The only remaining defect is a twist and anchylosis of the vertebræ of the neck, shewing that the bodies of these vertebræ were the seat of the disease.

the arms for the column of the spine, the propriety of confining him to the horizontal posture, and enjoining perfect rest, is abundantly indicated; and if neglected the spine projects backwards, the upper part of the body is projected forwards, and there is irremediable deformity should the patient recover from this alarming condition.



Section of the Thorax. The spine distorted by caries, but finally sustained by anchylosis.

The practice in such cases is accurately laid down in books; in the attention to preserve the body at rest—to subdue the fever—to support the constitution—and when recovering, to sustain the spine both against incumbent pressure and lateral motion. It is not my purpose here to speak of this case any further than to notice the distinction to be observed in contrast with other conditions of the spine, and to mark the difference between supporting and raising the body.*

It is one thing to prevent the weight of the body pressing on the inflamed surfaces of the diseased vertebræ; it is quite another thing to raise the column and make a chasm between these surfaces. In one period of the disease the body may be raised or stretched, and the stature almost resumed, and the projection of the vertebræ diminished. But such a practice is contrary to all principle, and highly dangerous; for when

* In the Collection of the College of Surgeons [Edinburgh] there are specimens of this disease, dissected by me during the more active period of my life. See the Catalogue, 330, XXI. D, "Vertebræ of the back carious; the disease has made great ravages; some of the vertebræ are united by bone; a small part of the 3d remains; the 6th and 7th are much destroyed; the heads of the ribs have partaken of the disease; the patient died of hectic fever." Ibid. 331, XIX. F. Here the abscess and the walls of the abscess are seen. 328, XIX. F. shews the inflamed state of the bone preceding the destruction. 332. XIX. F. shews the transverse processes anchylosed, whilst the bodies are destroyed. In 333 the spinal marrow is exposed.

once the disease has proceeded so far as to produce a hump upon the back, a chasm has taken place between the inflamed surfaces by the absorption of the body of one or more of the vertebræ, and the only hope of cure is the union of the surfaces. This union cannot take place if these surfaces are violently separated.

The attempt to elevate the body at a later period of the disease, when the surfaces are consolidating to anchylosis, may prove fatal. My colleague in the Middlesex Hospital was carried to the examination of the body of a young lady, who had died suddenly by this ignorant practice, and he found the vertebræ, which had united, broken asunder, and, as we might imagine, with the same effect on the spinal marrow as if from a recent fracture of the spine.—*See the Additional Notes*, No. II.

But my chief object in mentioning the scrofulous caries of the vertebræ is, that it haunts the imagination of patient and practitioner, and they lay down the patient in fear of this condition of the spine prevailing, when it is not present, by which they irrecoverably injure the constitution.

The mistake which leads to this unfortunate practice is not from ignorance of the actual disease of the spine, but from neglect of another department; inattention to the symptoms accompanying the condition of the uterine system. All changes of the ovarian

and uterine system are attended with sensations in the loins, and very often slight functional disorder is accompanied with pain in the loins. A young lady complains of weariness and lassitude, and pain in the back after walking. It will often occur, that, on examining the spine, and touching the prominent processes, she will start off and spring from the hand of the surgeon. These feelings, though very distinct from the true symptoms of carious vertebræ, are sufficient to give alarm, and it is presumed to be safest in the circumstances, that she should be laid down in the horizontal position, and avoid motion. This affords relief, and confirms the surgeon in his opinion. This is an unhappy result; since a young lady, at a critical period of life, when her constitution should be confirmed by every thing to promote health and strength, is condemned to inaction and the confined air of her chamber, which too frequently produce a weak hysterical condition, succeeded by a variety of undefinable nervous symptoms, that may puzzle the best informed physician. After the patient has been long confined, and is at last permitted or solicited to rise, she trembles in every limb, spasms affect the muscles of the neck, and she is obliged to resume her position from absolute inability to rise. She grows in stature, or rather in length, but without strength, and is weak, nervous, and hysterical.

I have seen the confinement enjoined so long and so strictly, that the body and limbs were drawn up and anchylosed.

I have found ladies further advanced in years, and married, treated for disease of spine, when it has been shewn that the whole malady was a dragging of the uterus. Some years ago, I was called into consultation on the case of a lady who had been confined to bed for eight months, and cruelly tortured by blisters and caustics to her back, when, upon due consideration of the nature of the weakness, discharge, and relaxation, I was convinced that there was no disease of the spine, but only descent of the womb. This case has been brought to my recollection by a similar one, whilst these papers are before me. As the dragging of the uterus is attended with pain and a sensation of weakness in the loins and back, as it is increased on walking and relieved on lying down, the patient's feelings readily coincide with the opinion of the surgeon that the disease is in the spine. As married ladies in these circumstances are sometimes cautioned against falling "in the family way," I may observe that pregnancy, by the mounting of the uterus out of the pelvis, is a natural cure; only let great care be given after delivery of such women, that the prolapsus does not recur.

Paraplegia does not frequently occur in young women, but when it takes place in older persons, it is apt

to be confounded with disease of the vertebræ; yet the symptoms, from first to last, are very distinct.*

The consideration of the different uses of the columns of the spinal marrow, the difference in the sensibility of the anterior and posterior roots of the spinal nerves, and the effect of disease of the bodies of the vertebræ in affecting their functions unequally, remove a great part of the uncertainty regarding paraplegia, as distinguished from disease of the spine, and from affection of the brain.

The pains and partial insensibilities consequent on caries of the vertebræ, whether caused by inflammation within the tube, or consequent on inflammation and abscess external and lateral to the spine, are subjects of great interest.—*See Additional Note*, No. III.

When the paralysis arises either from softening or from tumour of the spinal marrow, the absence of head-symptoms and the consideration of the peculiar functions of the cord will declare the seat of the disease.

* It is not surprising that the Pathology of this most important subject should be imperfect, while the functions of the spinal nerves were not known. If the reader will peruse the works of Dr Cooke on the various species of palsy, he will be surprised to see how little, learning and great industry did for him in the preparation of his two volumes. How little he could say, for example, and the confusion he has run into on the *History of Paraplegia*, vol. ii. p. 35.

It may be accident, but I have had ten to one cases of this palsy of the lower extremities in men, to that of women; with the exception of those cases of nerves, compressed by disease, in the pelvis and loins. In the commencement of the disease there is no complaint of pain, but only of a certain insecurity and want of feeling of the ground; the patient can exert the limbs powerfully, long after failing in directing the toes with a secure step. The slowness with which the limbs answer to the will, inclines them to fall forwards. They are unable to stand on one foot, or to put their foot in their trousers or shoe. In those rare cases where the defect of feeling accompanied the debility, it has had this singular effect, that when the patient has extinguished his candle he could not direct his steps to bed. Gradually the difficulty of walking increases; he walks with a straight knee; the limbs lose their firmness; then there is a hesitation and difficulty in expelling the urine. The abdominal muscles become weak, the bowels sluggish, and there is a constriction of the diaphragm. The lower part of the body having become insensible, we have to encounter sloughing of the nates, and from this cause and the irritation of the urine, fever is struck up, and then it is fatal. But the progress is very slow; in nine years I have in some instances hardly observed a progress. The diagnosis is certainly obscure. I believe that the disease, such as I have described it, results from a strumous soften-

ing of the spinal marrow. M. LONGET gives instances of the softening of one of the columns. I have found it occasioned by scrofulous tubercle.*

Falls, from the shock given to the spinal marrow, would, in some cases, seem to be the cause of disease in the spinal marrow. I have had a patient who, in consequence of a fall from horseback, had concussion of the spinal marrow. His symptoms in the beginning resembled commencing paralysis, but terminated after years in a singular rigidity of the trunk, with every appearance of the spine having become one bone by anchylosis. There was no distortion; on the contrary, he stood like a grenadier on parade, and could not stoop; but in lying down, he had to roll himself over. The limbs retained their office. The case reminded me of the many preparations of anchylosed vertebræ, which we have in collections.

To return to the subject of creeping palsy of the lower extremities. Since we know that the nerve fades in the absence of excitement, or of the due performance of the functions, whatever they may be, we must, in these cases, urge the patient to continued exertion, and aid him in this by artificial excitement; for this I have employed galvanism with effect.

* See Recherches Experimentales et Pathologiques sur les proprietés et les fonctions des faisceaux de la moelle épiniere, d'un examen historique et critique des expériences faites depuis Sir CHARLES BELL. Paris, 1841.

We now turn our attention to the congenital causes of distortion. I have found surgeons undertaking to correct deformities which were incurable, and in cases where it was dangerous to make the attempt.

As we see the cranium imperfect when the brain is so, as we see the spine defective when the spinal marrow is imperfect, so do the ribs and sternum conform to the state of the lungs. A narrow chest is supposed to injure the lungs, when it probably is indicative of a congenital imperfection in them; such imperfection being generally in one side of the chest, the spine must conform, and it is curved unnaturally. This deformity cannot be remedied by any mechanical means.

Young people have been sent to me for advice, when the curvature of the spine was consequent on disease of the lungs. The usual history runs thus:—that after some of the children's diseases, scarlatina, measles, or hooping-cough, there has been set up an inflammation of the lungs. The lungs of one side become consolidated, or empyema forms, and on the discharge of the matter, the lateral cavity is diminished, the diaphragm rises, and the ribs draw together, and one side of the chest is less than the other; to this side the spine inclines. This curvature is distinguishable from the "lateral distortion" by the uniformity of the arch. It has not the sigmoid form; it is a uniform bend of the dorsal vertebræ. On looking to the front, the in-

equality of the sides of the chest is manifest, and the percussion of the defective side is conclusive.

It occurs to me as possible that cases of this kind have given rise to the opinion, that lateral curvature begins in the vertebræ of the back. There is hardly an excuse for the mistake; and as for the very weak theory, and the very wrong practice founded on that theory, I have not words to express my disapprobation. The judicious notice of this subject in the *Notes*, relieves me from speaking of it. We should betray ignorance in proposing, for this inclination of the spine, the mode of cure, which is harmless and effectual in the case of lateral curvature.

As to the means of distinguishing rickets from the pure lateral distortion or sigmoid distortion of the spine, the marks are obvious. We first notice the shortness of the lower extremities,* the smallness of the pelvis, the awkwardness of the gait, and projection of the hips and protrusion of the belly. The lower part of the column, the vertebræ of the loins, have fallen with a curve forwards and into the pelvis, which both protrudes the belly and makes the loins to fall in. In a greater degree, we find the tibiæ sinking above the ankles, and the thigh-bones curved. The bones are not merely distorted by the weight they bear, but twisted

* See a paper by Mr ALEXANDER SHAW on Rickets, in the *Med. Chirurg. Trans.*

by the action of the muscles. In the face there are distinct traits: the forehead projects,—the eyes appear large,—the lower jaw has yielded to its muscles, and the chin is prominent. The chest is unnaturally flattened, or sometimes squeezed laterally; the clavicles are prominent and curved.

If the disease be still progressive, the stomach is prominent, the countenance pale, and the features sharp. The respiration is short and abdominal; the appetite unnatural, and the bowels disturbed. The child is feverish, with a quick pulse and night-sweats. The limbs lose their flesh, and the articulations appear large. With all this the mind is precocious, and the sensibilities are unnaturally acute. It is a disease of childhood, and does not occur after puberty. It is the consequences of the disease which require to be studied, as bearing a resemblance to the lateral curvature of the spine, and these, from their nature, give little hope of amendment by any means we can pursue. If we examine the pelvis, besides being unnaturally small, we shall find it obliquely pitched; and on further examination, we shall discover that this obliquity results from the greater degree of distortion of the tibia and femur of one side.

The *Mollities ossium* is a diseased condition of the bones, which does not come into discussion in the cure of lateral distortion of the spine. It occurs at a later

period; it will be indicated by the diminished stature, and the sinking of the ribs into the pelvis. This is the first stage, for the spine first gives way, and the vertebræ of the loins are pushed down into the brim of the pelvis; the loins consequently sink in, and the hips project backwards. The obvious loss of health, the hectic, the pain in the bones, and the deposit in the urine, characterise the progress of the disease. It is slow in progress, and sometimes so slow that I have had a patient suffering under the complaint for the greater part of my active professional life.*

In alluding to the mistakes committed in the case of lateral distortion, I have to notice that which arises from inattention to the state of the lower extremity. A young person has suffered a "blight" which has arrested the growth of one of the limbs, and this gives a "pitch" to the pelvis, and that produces a curvature of the spine. The defect will be found to have extended to the whole of one limb from the toe to the spine of the ilium. If the surgeon takes a tape and measures the length or girth of the leg, or thigh, or knee, he will find them less than the dimensions of the other extremity. The ilium belongs to the limb,

* One of my patients, suffering under Carcinoma mammæ, had her humerus broken by the hand of the nurse in tenderly assisting her in bed. But Mollities ossium is a specific disease, and neither arises from syphilis, nor scurvy, nor rheumatism.

and it will be found to partake of the defect of the limb; it is smaller than the bone of the other side. The spine, reared on this oblique foundation, necessarily inclines at the base; and as it is a flexible column, and as the body must be *a plomb*, it bends again towards the centre, and is in form the same with the true lateral curve. We cannot remedy this but by removing the cause, by making the pediment level; and this can only be done by the patient wearing the high shoe, which may not, on other considerations, be advisable.

There is still another cause of obliquity in the pelvis which the practitioner must have in recollection,—disease of the hip. As in disease of the hip, when the sufferer has been long confined, the pelvis is raised on the diseased side, and obliquity given to the base of the spine, the vertebræ accommodate themselves, and a curve is established, with all the consequences which we have now more particularly to describe.

Of the Lateral, or Sigmoid, or Complex Curvature of the Spine.

The young lady walks awkwardly into the room, with an unequal step, and with the left haunch projecting. If she has been quite neglected, the right shoulder projects. But if she has been under a ma-

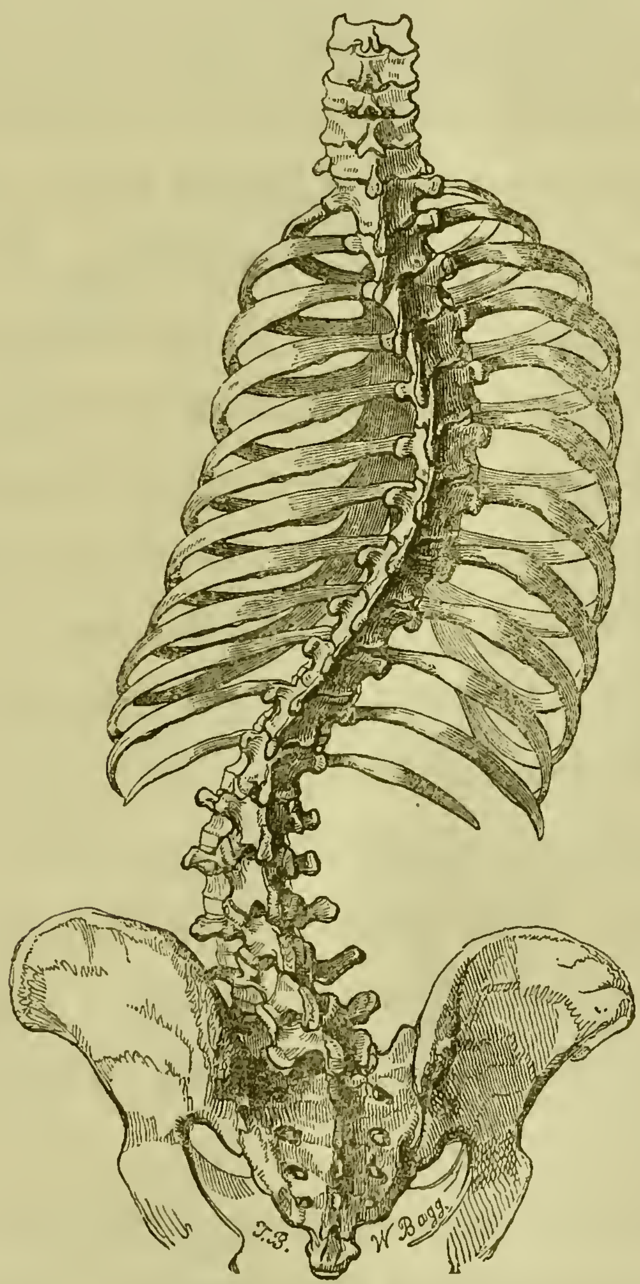
ternal eye, and her carriage attended to, this sign of distortion of the spine may have been in a certain degree diminished by frequent admonition. If she be made to lie on her back stretching the lower extremities, the right leg will appear longer; but if the cord or ruler be put to the heels, and then across from the one superior spinous process to the other, the pitch of the pelvis will be found to be oblique, and to correspond in obliquity with the heels.

It is not uncommon for the mother or governess to bring a young lady for consultation on account of a projection of the right shoulder, or an enlargement of the left breast. These are consequences of the distorted ribs, which, again, are consequent on the curvature and revolution of the spine on its long axis.

To expose the back, the corsets are removed and a shawl put round the girl; and now it will be observed that the lower angle of the right scapula is thrown out, and its base lies obliquely to the spine; that the left scapula has its base parallel to the spine, but much nearer than it ought.

And now, running the finger along the spine, it will be felt that it takes the sigmoid direction or form of the italic *S*. Looking to the lower part of the spine, it will be seen to pass off from the sacrum obliquely to the left side. Following it up, it bends to the right, and with a curve, chiefly in the dorsal vertebræ, con-

vex to the right side, and concave to the left side. If the curvature has been long neglected, there will be an abrupt deviation of the spine at the lower part of the dorsal vertebræ. At the neck, the spine becomes again perpendicular to the base, thus completing what is distinguished as the sigmoid or lateral curve. See *Additional Notes*, "*Danger of mistaking lateral caries*," No. IV.



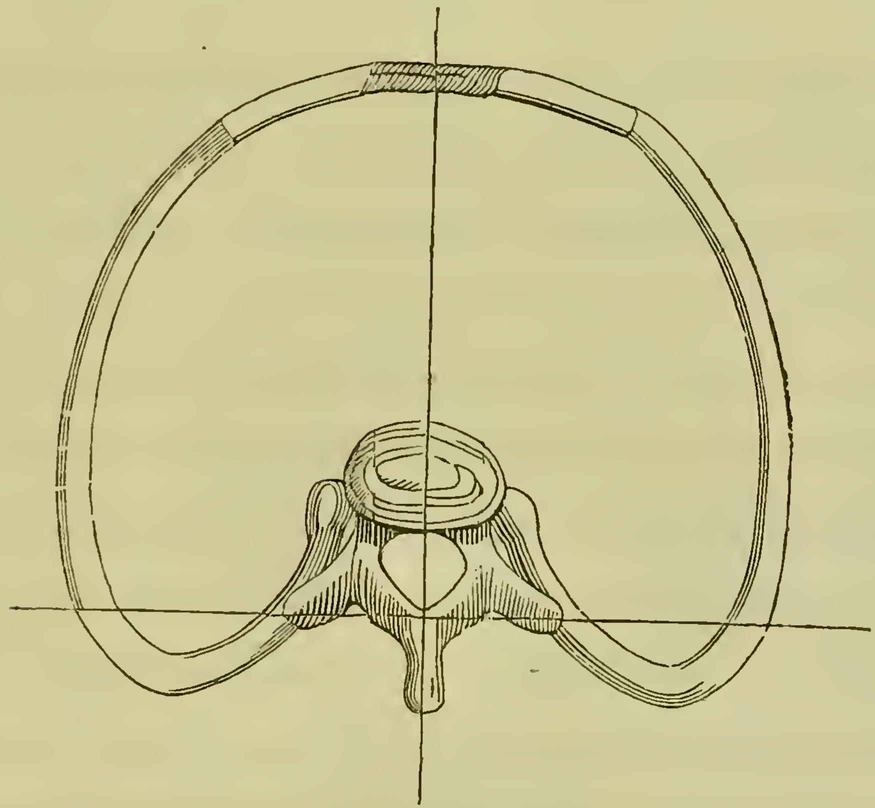
There result from this form of the spine some remarkable effects. First, the expansion of the chest on the right side, and the diminution of the left. This is seen on looking to the back; whilst, on looking to the fore part, the left side of the chest is projected. Hence it is, that the scapula of the right side is heaved up, resting on a greater convexity, and thrusting out the shoulder; whilst the left scapula lies flat on the depressed ribs of that side; and hence also the prominence of the fore part of the chest on the left side.

It must be especially observed, that this distortion of the spine is not merely a lateral curve; the column is twisted or turned on its long axis. The effect of this is very particular. First, in the loins, it causes the transverse processes of the lumbar vertebræ of the left side to project, so as to thrust out the long muscles of the back, and chiefly the longissimus dorsi and sacrolumbalis. Whilst a fulness by this means is presented on the left side of the spine, in the loins, there is a flatness or hollow on the right side. Exactly the reverse of this takes place in the upper part, or the dorsal vertebræ. The spine is turned round from right to left below, and from left to right above. See the judicious remarks of Mr Shaw *on cutting the muscles of the back*, Note VII.

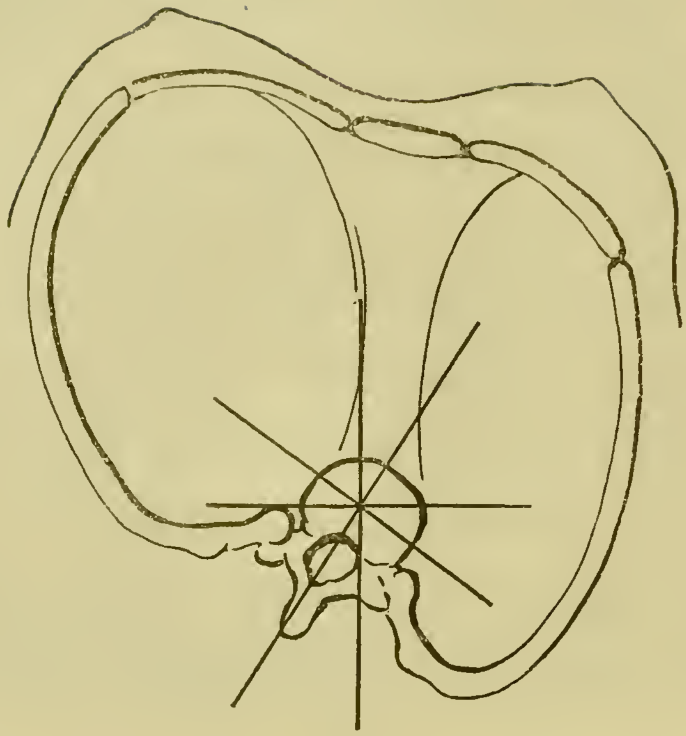
The unequal prominence thus given to the long muscles of the back, has led to a strange mistake—nay, to

a theory !—some authors, attributing the whole to a disease of the muscles, and pointing to the fulness on the left side of the loins as a hypertrophy of the muscle, and to the depression on the other side as an atrophy. There is a certain imperfection of the muscles, consequent on distortion, from their being thrown out of use. The exercises presently to be noticed are necessary to the restoration of the muscular activity.

Mr SHAW has well explained, by these outlines, the effect of the upper twist, or revolution of the spine.



Suppose we present a horizontal section of the trunk thus, what will be the effect of the twist which brings out the lateral processes of the vertebræ on the right side? It will be this.



That whilst the angles of the ribs project behind on the right side, the left side of the chest, and, consequently, the left breast, will be made prominent on the fore part.

Upon the whole, then, the effect of the lateral or sigmoid distortion is to produce an ungainly walk, to curtail the girl of her natural stature, to disfigure the bust, or neck and shoulder, and to push out the left breast. But, more, if permitted to increase, (and it is of a nature to increase when once the bias is given) the capacity of the chest is diminished, and the lungs compressed, with consequent injury to the general health.

Origin of the Lateral Distortion.

The cause of this curvature of the spine is very obvious; it takes place in young females of delicate frame, but not rickety. In scrofula, the extremities of the fingers are often enlarged or bulbous,—in girls, subject to this form of distortion, the fingers are long and tapering, and such as a painter gives to the ideal beauty of the Madonna. They are very generally children of the higher classes of society, implying, that preposterous notions of female accomplishments are entertained, by which the girls are precluded from natural activity and exercise. They languish under restraint, and become liable to muscular debility and weariness, which is the first and prevailing cause of the evil.

What is the posture of a person thus wearied by muscular exertion? what is the natural position of the statues of the Athletæ? what is the position of the soldier "standing at ease?" They rest on their left leg, throw loose the right, and thus the pelvis has an obliquity or *pitch*, which throws the spine to the left side. The flexible spine preserves the trunk of the body perpendicular to the base on which it rests, by inclining to the right; and when once this inclination is given, the girl finds it easiest to balance the body by resting on the right leg. In all paintings and statues, we per-

ceive how resting on one leg gives the line of beauty, that easy and varied curve which the artist is taught to admire, and which we now see is true to nature.

But if a languid and wearied girl is permitted to stand so, or, to use the Scotch expression, to *hang* on her feet, the line of beauty in the spine becomes the form of permanent distortion; for the necessary consequence is the spiral twist of the spine itself, and the unequal expansion of the sides of the chest. The distortion of the spine is not a simple inclination laterally, but a complicated twist. The vertebræ of the loins revolve on their axis, so as to bring the transverse processes more superficially than is natural. This twist, as well as the lateral inclination, is counteracted by a natural effort, and hence the spine is twisted above, in a manner different to what it is below. The exercises to correct this complex distortion must be adapted with some precision. From this statement, we perceive how a person, intended by nature to be elegant, becomes deformed, and it may be an "object." *See Additional Notes*, No. V.

There is another class of females subject to this form of distortion, sempstresses, who, sitting at work, habitually throw one leg over the other knee, producing obliquity of the pelvis and all its consequences.

When once the bias is given in distortion, the girl finds the position of ease to be that which corresponds

with the curves; and in writing, drawing, or working, the shoulder is still elevated, and the left side of the chest compressed, and so the deformity is fixed. She is now subject to wearisome pain in the side. *See Additional Notes*, vi. *on the condition of the Spinal Marrow consequent on that of the Spine.*

The method of cure of this deformity is implied in the above detail of its causes, in attention to the general health and strength, and in regular and varied exercises.

The spine, constituted of bone, cartilage, ligament, elastic ligament, and muscles, must be perfect in all these or in none; exercise is the stimulus to all, and without it, the spine sinks. The numerous muscles, and their tendons inserted into the processes, become feeble, the ligaments relax, the cartilages soften, and even the bodies of the vertebræ become light and spongy; whilst, on the contrary, every part becomes firmer by exercise. The muscles, especially by varied action, brace the spine, and correct the deviation from the true direction.

These essays being written principally for the advantage of my own pupils, certainly suggested by the desire that they should keep just principles before them, in the prosecution of their profession, I am tempted here to notice those theories which have been propagated on the cause of lateral distortion. The distortion is at-

tributed to disorder of nerves : to the spasm of muscles. It is even classed with Tetanus! A simple deviation from the correct form, which throws certain parts out of use, and therefore leads to a consequent imperfection, is attributed to I know not what formidable source. At one time, to a scrofulous degeneration of the ligaments which permits the spine to fall, at another, to some inexplicable spasm of the muscles of the back, which pulls the bones into distortion. This last idea has been taken up from the unequal prominence of the muscles, consequent on the spiral twist of the column.

All exercises should be gentle at first, and gradually increased; put a young horse to its speed, and its muscular power is too much for the resisting strength of the apparatus of its joints. It "breaks down." A "danseuse," though accustomed to exertion, must, on every occasion, commence her exercises with gentler motions of the feet, and the throwing out of the limbs, before she springs upon the stage; her exercise behind the curtain, being acknowledged to be greater than her efforts before the audience. This, which experience dictates in professional people, must not be neglected in treating delicate girls by exercises to correct the curvature of the spine.

Exercise of the baton or club.—Ignorant people put their young female pupils on the exercises appointed for the British army, to strengthen the sword-

arm of the cavalry. Were this effectual, it would give massiveness to the shoulders and arms; certainly not a desirable thing for a young lady. The proper mode is this. Let her lay hold of the ring of the baton with the thumb and forefinger, the thumb being turned down; so holding it, it hangs like a plumb-line, and she is to carry it so, hanging perpendicularly, round the head. This she cannot do without inclining and twisting the body, which being done by the flexibility of the spine, is the thing desired; for unless the twist of the vertebræ on their axis be counteracted, the lateral curve will not be corrected. The club thus brought round the head to its first position, is to be taken in a similar manner by the other hand, and brought round on the opposite side; and thus repeated, the muscles of the spine, and all the apparatus of this intricate column, are put into exercise and play. The outline, No. 2, Plate III. exhibits the mode of using the baton, and its effect in counteracting the curve of the spine, and in expanding the contracted ribs. Although the exercise with the left hand has direct influence upon the gibosity of the thorax of the right side, I order both sides to be exercised.

Other exercises for the slighter cases may be practised with little inconvenience in a school-room. By the very simple contrivance represented in the figures

Nos. 3 and 4, the spine is put into full and safe exercise.

With regard to the inclined plane, some remarks will be necessary. The patient should not be permitted to stand nor to sit, unless occasionally, and for a short time. When really active, she is suffering no harm; but standing or sitting indolently is injurious. Therefore she should always rest in the inclined position.

The plane on which she reclines, fig. 5, is in two parts, and on wheels. Whilst she is reclining on it, lying on her back, the upper portion of the plane is fixed, whilst the lower is let loose, so that slipping down a few inches, it gently stretches the spine.

It is proper to use cushions to the more prominent part, higher on the right side, lower on the left, thus applying a lateral pressure in aid of the elongation of the spine. The plane is calculated to assist in exercises. When the lower part is removed, the patient lies upon the upper part, fig. 6, on her face, and with her hands she draws herself up, at the same time throwing up the head, and curving the spine backwards. If there be great falling in of the lower part of the spine [and this will be the case if rickets has been the complaint], she should lie on her back, and taking hold of cords attached to the pins, draw herself up.

I have been in the use of sketching on a sheet of paper how the exercises are to be performed, and the chief rules to be followed, and I have caused such outlines to be engraved here, as conveying my advice in the most intelligible shape.

ADDITIONAL OBSERVATIONS ON THE DISEASES OF THE SPINE, BEING NOTES ON THE FOREGOING ESSAY. BY ALEXANDER SHAW, ESQ. OF THE MIDDLESEX HOSPITAL.

NOTE I.

CONDITION OF THE ANTERIOR SURFACE OF THE VERTEBRÆ WHEN CARIOUS.

Let us suppose that caries of the spine has occurred in a person at an early age, and that it has passed through its various stages in a mild form, without giving rise to worse effects than distortion, the following may be taken as a correct account of the changes which the parts have undergone.

The disease consists essentially of a progressive ulceration of a certain part of the bodies of the vertebræ and intervening fibro-cartilages. As the process of destruction goes on, pus is secreted from the diseased surfaces. But the quantity of this matter differs greatly in proportion to the extent of carious bone in different cases ; and its character also varies. From appearances presented in the dissection of two patients with caries of the spine lately under my care, one of whom died from inflammation of the lungs, and the other from ulceration and hæmorrhage in the intestines, as well as from other examinations, I am led to infer, that

when the disease is of a mitigated character, tending towards a cure, the amount of purulent matter in contact with the carious vertebræ is extremely small when compared with the extent of ulceration. During the advance of the caries, an important change goes on in the cellular texture and ligamentous membranes which surround the vertebræ. These structures become thickened and accommodated to the angle produced by the falling together of the bones. Consequently, a kind of capsule, more or less approximating to the diseased parts, and embracing them, is formed in front of the column.

The purposes served by this capsule deserves attention. It not only walls in the diseased vertebræ, thereby limiting the extension of the suppuration, but, like a ligament, it prevents the column being straightened at the seat of the disease. By thus tying down the carious vertebræ, and preserving their surfaces in contact, it has the double advantage of warding off danger from the spinal marrow and promoting anchylosis. Were free motion allowed at the diseased part, the spinal cord would be exposed to the continual risk of being injured, either by the column being suddenly raised to a straight line, or as suddenly allowed to drop into the angular condition. Again, it is obvious that unless the opposing surfaces of the vertebræ were retained in contact, ossific union between them could not be procured, any more than we should expect the broken fragments of a femur to unite when the extremities were kept apart. Accordingly, we conclude, in reference to this membranous structure, that the shorter and more closely adherent it is to the diseased

vertebræ, so much the more effectually will it answer the important purposes that we have pointed out.

What, then, are the more remarkable effects on the spine produced by the measures employed by persons professing to restore the figure in this kind of distortion ?

NOTE II.

DANGER OF THE TREATMENT BY UNEDUCATED PERSONS.

Let me notice that patients are carried to these practitioners, affected in very different ways, or where the disease exists in different stages. For example, in some cases, the vertebræ may be firmly united by anchylosis ; in others, the union may be incomplete, being partly osseous and partly membranous ; or, lastly, the bones may be held together exclusively by membrane. In all these instances, the pain in the back may be inconsiderable, and the patient's health not seriously disturbed.

The system of treatment commonly pursued, consists mainly of keeping the child continually in the recumbent position, with a force operating on the spine to elongate it. But that the practitioner may not want occupation, he daily kneads the angular projection with his fingers, for the purpose, as he explains to the friends, of reducing what he calls the dislocated bones.

In no long time after the treatment has commenced, and

without any bad effects displaying themselves, it may happen that some improvement will be manifested. Now, how is such amendment in the figure to be accounted for?

In a case where the affected vertebræ, after the subsidence of the ulceration, have become firmly united by bone, it is easy to understand that the elongation and thumbing of the spine can do no actual harm ; but what is the change effected in the column, which both improves the figure of the patient and elevates the credit of the practitioner?

The explanation which *he* gives, namely, that his success is owing to his daily manipulations, is, of course, not worth remarking upon.

It has to be remembered, that in the kind of deformity of which we are treating, although ulceration of the bodies of the vertebræ is the direct and chief cause of the column bending forwards, it is not the only cause. As the caries proceeds, and after it has ceased, the spine continues to bend and sink under the superincumbent weight, owing to the effects of the pressure on the *sound* parts of the column, above and below the seat of disease. It results from the weight of the body bearing upon the spine in the new direction given to it by the disease, that these parts receive the pressure obliquely, or off the perpendicular line ; and they are therefore incurvated and depressed to an unwonted degree. Now, this incurvation and sinking of the sound parts, have the effect not only of making the whole spinal column and trunk appear shorter, but they tend to make the projection of the spine, primarily caused by the caries, more prominent than it would otherwise have been. Accordingly, when we reflect

on this circumstance, it is not difficult to explain the source of the benefit derived from mechanically stretching the spine. The force employed can have no influence in changing the condition of the anchylosed part; but all its effects must operate on the divisions of the spine above and below that part. It will bring these divisions into a straighter line with reference to each other; and that, again, will elevate the trunk and diminish the prominence of the angular projection. These results correspond with what we observe in casts made to exhibit the improvements in such cases. Looking at the whole spine, its height is increased, and it approaches nearer to a perpendicular line than it did at first. But we can easily discern that no alteration has been wrought on the true seat of the distortion. The general fulness and projection of the vertebræ originally diseased, mark distinctly that the spine deviates from the straight line at that part as much as it ever did.

But at what an immense risk is this improvement of the personal appearance, such as it is, obtained!

In the first place, the case which we have supposed as subjected to the treatment, has been one wherein the active stage of the caries had ceased, and anchylosis had taken place. But how are we to satisfy ourselves, in actual practice, that such an event has happened? Can any surgeon, the best educated, or of largest experience, assert with confidence, in particular cases, that the disease has absolutely stopped, and that there is no danger of its being lighted up and exasperated by the violence employed in the treatment? And if he commit a mistake, what disastrous results ensue?

The spine is not like a columnar bone of the extremities; we cannot, by any nicety of tact, decide when union between the carious vertebræ has occurred. The natural general flexibility of the spine precludes the possibility of our doing so. Again, so insidious and long continued is the progress of ulceration, that we ought always, even for years, to hesitate about pronouncing it cured. At one time, at no remote period, three young men were lying in two adjoining wards of the Middlesex Hospital, all affected with psoas abscess, consequent on caries of the vertebræ. The disease carried two of the patients off, and the remaining one narrowly escaped. Their ages varied between fifteen and five and twenty. Now, the important point that I remarked in these cases was, that in the whole three, the disease began during their early childhood; and, until only a short time before their reception into the house, they had been able to pursue laborious occupations.

Hence, there is invariably a difficulty of deciding what is the real state of the diseased parts, when angular projection of the spine exists; and that uncertainty—when we think of the formidable injury the treatment may cause, compared with the unspeakably trifling benefit it may procure—is of itself a perfectly decisive argument against adopting the treatment.

Let us mark only what will be the necessary effects of employing a force to draw the spine into a straight line, when the union between the vertebræ is incomplete. One consequence will be, that the opposing surfaces will be separated from each other to such a degree that adhesion be-

tween them will be physically impossible. This circumstance, conjoined with the continual motion involved in the operation of stretching, will therefore, to say the least, prevent the process of anchylosis being completed. But another directly disastrous effect is to be anticipated. It is true that, especially in children, the general elasticity of the spine is a wonderful safeguard against some of the evils that we are apt to prognosticate. Nevertheless, an occurrence of this kind has happened ; and no one can say how often similar things may have happened. The diseased vertebræ, forming an angle, have been held together in that position, partly perhaps by osseous matter, but in a chief degree by membrane. This membrane, owing to the ulcerative process in the bones, has adhered imperfectly to the part with which it was in contact. Now, the effect of maintaining a forcible extension upon the column, and pressing with the fingers on the angular projection, while the patient lay on his face, has been to lacerate the connection of the membrane with the bones, to tear this adhesion up, and, by suddenly reducing the angle, give a fatal shock to the spinal marrow. The chance of an injury of this kind will, of course, be greatest in those parts of the spine which are naturally weakest. Thus, I have seen a preparation of the vertebræ of the neck, where sudden death was produced in the manner described. The practitioner, who enjoyed some years ago a popular celebrity of its kind, was employed pressing with his hands on the projecting vertebræ, when the parts at once gave way, and death suddenly ensued. A large abscess that had burst,

was found in contact with the bodies of the cervical vertebræ, several of which were absorbed by ulceration.

NOTE III.

OF PAIN CONSEQUENT ON DISTORTION OF THE SPINE.

It is not unfrequently a matter of importance to discriminate between the different causes that give rise to *painful sensations*, and *muscular affections*, in caries of the vertebræ.

This will be understood, when it is stated that the symptoms alluded to sometimes owe their origin to the nerves external to the spine being involved in the diseased parts around the carious bones; and, at other times, are signs of the disease having reached the spinal marrow, and involved that organ in the morbid action.

The case is similar to what we find in the brain. Certain painful or paralytic affections give alarm, because they appear to depend on disease seated within the skull. A satis factory explanation of the symptoms, however, may be obtained, in many instances, by observing that the parts affected are confined to the distribution of a particular cerebral nerve, with the functions of which we are acquainted. That point being ascertained, we conclude that, not the brain, but a nerve, is the source of the affection; that one of the nerves of the brain, after quitting the skull, has become in-

cluded in a disease situated at a distance from the brain, somewhere in its course towards its distribution.

There are two kinds of morbid changes connected with caries of the vertebræ, which, by involving the nerves after their departure from the vertebral canal, may give rise to loss of sensation and motion. These changes depend on very different conditions of the disease.—1*st*, When suppuration induced by the caries extends along the column, the walls of the abscess may at length include the nerves in their substance, or cause pressure upon them, in such a manner as to destroy their functions. 2*dly*, When the active stage of ulceration has passed, and anchylosis is in progress, it may happen that the mass of callus, or of ossific matter, forming the bond of junction between the vertebræ, will involve the nerves, and produce similar effects.

In a case where the nerves of the spine have lost their functions, independently of the spinal marrow, by either of the modes just described, there is a greater difficulty of recognising the true nature of the affection, than when the nerves of the brain have been involved outside of the skull. This will be understood if we remember that, whereas the functions of the spinal nerves are double, each nerve possessing motion and sensation, those of the cerebral nerves are single, and therefore more distinctly contrasted with those of the central organs.

To illustrate my meaning, let me take the example of the portio dura, or of the Fifth pair. When the former of these nerves, distributed to the face, has had its functions destroyed, whether from disease within the tympanum, or compres-

sion by a deeply seated gland in its course, we recognise the nature of the affection, by observing that it is motion alone that is lost in the parts to which it is sent; that the sensibility of the face remains as acute as at first, and that pain has been entirely absent. Had the brain been morbidly affected, both the endowments spoken of would have been affected, and pain would have been one of the symptoms. Indeed, the absence of pain, in the case of disease of the portio dura, offers one of the most striking illustrations that can be obtained, of the complete distinction between a nerve intended for motion, and one intended for sensation. When a patient is struck with paralysis of the face, he has no previous warning of the event from pain in the part; on the contrary, even after the paralysis has taken place, he remains unconscious and unsuspicious of the occurrence; and it is not till he looks at his face in the glass, or some acquaintance informs him of the distortion of his features, that he becomes aware of his misfortune. What does that fact imply? It shews that even the process of disorganization of the nerve, which has been so effectual in its nature as to deprive the nerve entirely of its functions, has not had any influence to make it convey an impression of pain to the sensorium. So with regard to the fifth pair. When the branches of that nerve derived from the ganglionic or sensitive root, and which emerge upon the face, lose their function from disease in their course, it is sensation alone that is destroyed; the motions of the features, whether under the control of the will or influence of emotion, are retained in a perfect condition. Pain, too, and that most aggravated, attends the pro-

gress of the disorganization of the nerve, presenting, in that respect, a forcible contrast with the portio dura. But what we have particularly to remark in this place is, that when the branches of the fifth pair are involved in disease, it is sensation alone that is lost; instead of both motion and sensation being impaired, which would follow from the brain being affected.

Let us consider now the effect upon the spinal nerves, when, owing to morbid action at the outside of the spinal canal, their functions are destroyed. As these nerves are compound in that situation, consisting of the root of motion and that of sensation combined, it is obvious that, when injured by disease, they will lose both these properties simultaneously. Hence, it must follow, inasmuch as the power of giving motion and sensation is the characteristic endowment of the spinal marrow, and as, in severe injuries or diseases of that organ, both these properties are lost at the same time, that a difficulty will be presented in practice, in regard to determining whether the affection proceeds from the nerves exterior to the spine being implicated, or from the spinal marrow being affected by the caries. How may such a question be solved?

The difficulty will, in most cases, be removed by attending to a pathological fact, for the understanding of which, as well as of the preceding observations, our minds are prepared by Sir Charles Bell's discoveries and observations on the Nervous System.

As caries of the spine invariably begins in the bodies of the vertebræ, it is natural to conjecture that, when it ex-

poses the vertebral canal, the anterior part of the spinal marrow, from its proximity to the disease, will be the first to suffer. Hence, as the anterior column, in all its length from the third pair of the brain to the last anterior root in the cauda equina, gives origin to nerves of motion alone, it is to be expected, that, in caries of the spine, the first symptom of the spinal marrow becoming involved in the disease, will be loss of motion below the seat of the caries ; and that is in reality what we find. Scarcely will a case be met with where it will not be perceived that the limbs have been paralysed as to motion, for some time previous to any affection of the sensation. Moreover, it will commonly be found, in cases where at length both functions are impaired, that the loss of motion is more complete than that of sensation.

There is a point in the anatomical structure of the spinal marrow bearing on the above subjects, which claims to be noticed at this part, namely, the difference between the situation of the columns for motion and sensation in the cord ; and their comparative liability to be involved in disease originating externally.

It may first be remarked, that the only certain method by which physiologists can decide the question, as to which of the distinct tracts of the spinal marrow is appropriated for sensation or motion respectively, is by anatomical observation. For ascertaining the separate endowments of the different columns, little can be done by experiments made directly upon the spinal cord. Such a mode of inquiry is inconsistent with the delicacy of that organ, and the situation it occupies. No part of the body holds its functions by so

slight a tenure as the spinal marrow,—is so easily deprived of its endowments by injury—or is so difficult to be reached in an experiment, without using such violence as to destroy its functions. The only way, then, on which dependence can be placed, for determining which column ministers to motion, and which to sensation, is to trace the distinct roots possessing these two powers into the different columns ; and when we have satisfied ourselves by such examination, as to the particular tracts that give off the roots in each case, we are in a position to distinguish the functions of the one column from the other.

Pursuing that course of observation, doubts may arise among anatomists as to the definite boundaries of the different columns alluded to. But there is one point about which they will all agree, namely, that the column from which the nerves of motion are derived, is situated *superficially ;* while the column that gives origin to the sensitive roots, is lodged *deeply.*

This is a point obviously of great importance in studying the pathology of the spinal cord. I will, therefore, state briefly how the conclusion is arrived at.

The fact is established in the following anatomical evidence ; and, to my mind, no evidence can be stronger. If we take the anterior or motor roots, and, observing their fibrils, follow them till they are lost in the spinal cord, we shall perceive that, as they approach the column to which they tend, each fibril splits and subdivides into numerous minute radicles ; and these radicles, before they become actually connected with the column, get so fine, that they are scarcely distin-

guishable by the naked eye. In short, the anterior roots arise so clearly from the surface of the cord, as contrasted with its actual substance, that instead of their springing out of the column, they seem rather to adhere to its superficies by a mere slight contact. The contrary is the case with regard to the posterior roots. The fibrils composing these roots do not undergo any subdivision into radicles, previous to reaching the spinal marrow. So far from that, they dive bodily, and of their original thickness, into the substance of the cord; and it cannot be questioned that to reach their destined and proper origin, they pass directly into the interior. This contrast, therefore, affords a distinct demonstration, that whatever may be the exact limits of the tracts, the column, from which the roots of motion arise, is placed superficially in reference to the whole cord; and the column from which the roots of sensation arise, is situated internally. Further evidence, I must not omit to state, of the tract subservient to sensation being lodged deeply, is presented by tracing the sensitive root of the fifth cerebral nerve to the spinal cord. That root of this nerve, which has a ganglion upon it, and corresponds in structure and functions to the posterior roots of the spinal nerves, descends, as it is known to anatomists, through the substance of the pons varolii, from which it appears, at first view, to take its origin, as far as to the commencement of the spinal marrow. By observing the track in which this sensitive root of the fifth pair terminates, and comparing it with the tract into which it appears most clearly that the fibrils of the posterior roots of the spinal nerves are inserted, we perceive that it is the same tract

throughout; and that the sensitive fibrils of the fifth pair and of the spinal nerves, all arise by a common origin. Now, when we look more attentively to the relative situation of this common tract, as compared with the other columns of the cord, we cannot fail to admit that it is lodged deeply; and that, instead of its being situated quite at the posterior part of the cord, it is in front of the posterior column, and corresponds with that termed the postero-lateral.

It may, therefore, be deduced from the preceding observations, that when the spinal cord becomes involved in disease, owing to extension of caries, and motion in the inferior extremities is lost before sensation, the latter phenomenon may depend upon two distinct causes. 1*st*, As I have already stated, the anterior column of the cord, which confers motion, may be destroyed before the column of sensation, owing to the anterior column being situated nearest to the bodies of the vertebræ, in which the disease originates. 2*dly*, From the anterior column occupying an anterior and superficial part of the cord, instead of being, like the sensitive column, lodged deeply, and protected from external injury, the effects of the diseased action may reach this column of motion, so as to produce destructive disorganization of its substance, sooner than any other part.

Applying now the above views to the object of distinguishing between affections of the nerves of the spine and those of the spinal marrow, we may perceive how they will aid in forming a diagnosis. When the disease has involved the nerves outside of the vertebral canal, both motion and sensation will be lost simultaneously; because in this situation

the nerves are composed of the roots of motion and of sensation united together. If, on the other hand, the caries has spread, so as to expose the vertebral canal and implicate the spinal marrow, the disease will affect the anterior roots of the nerves ; and if extending to the spinal marrow itself, the anterior column will be affected before the other part, and the power of motion will be destroyed, and that probably for a considerable time before sensation is diminished.

NOTE IV.

DANGER OF MISTAKING THE CARIOUS VERTEBRÆ FOR SIMPLE LATERAL DISTORTION.

Cases are sometimes met with in practice, where considerable difficulty is felt in deciding whether the distortion depends on caries of the vertebræ, or is only a case of incipient lateral curvature. The cases to which I refer are those where ulceration of the bodies of the vertebræ takes place principally at their lateral parts, so that, as the column yields under the weight, it bends to one side more than the other. When a patient is brought to us with that kind of complication, there is a lateral curve at the seat of the disease conjoined with the projection posteriorly ; and, as far as my experience allows me to judge, it takes place most frequently at the lumbar region, where motion of the spine is naturally freest. Within a few months past a young lady was brought

to me from the country, accompanied by her surgeon, a man of intelligence. The last dorsal vertebra, and the three superior lumbar, formed together a slight projection ; while there was combined with the prominence a decided inclination of the column to the right side. The patient had the strumous diathesis ; she had dull pain in the seat of the distortion, aggravated by motion, or sitting long erect ; pains, with slight cramps, were occasionally felt in the thighs ; and when she walked, her gait was constrained and irregular, like a patient labouring under lumbago. Before all the symptoms here noted had manifested themselves, which was for about four months before I saw her, the surgeon, considering the case to be one of lateral curvature of the spine at its commencement, had set the patient on a system of exercises adapted for that deformity. After giving my opinion that the affection depended on ulceration of the vertebræ, calling for absolute rest and other measures, to prevent the spreading of the caries, the patient returned into the country ; and I have since learned that paraplegia has supervened.

In this instance, the appearances in the spine resembled those of incipient lateral distortion more nearly than in any other case that I have witnessed,—that is, on the left, or convex side of the curve at the lumbar region, there was an increased fulness, a character that belongs to lateral curvature ; but, on attending more accurately to the bulging referred to, it could be perceived that, instead of its being formed by the transverse processes thrusting out the great extensor muscle of the back, which is the cause of the fulness in lateral curvature, the prominence was distinctly owing to the spinous

processes projecting superficially, and pressing against the integuments. This latter circumstance is to be esteemed highly important, as enabling us to distinguish between the cases in question. In lateral distortion the spinous processes cannot be felt but with great difficulty. Owing to the rotation of the spine formerly adverted to, they are turned so much to one side, and the longissimus dorsi muscle overlaps them in such a manner, that it is only by pushing the fingers under the edge of that muscle that we can touch them; and it is the transverse processes, covered by the longissimus dorsi, which present themselves most conspicuously.

NOTE V.

OF LATERAL DISTORTION—ADDITIONAL REMARKS.

That this kind of deformity is so frequent in families where the figures of the children are watched with all care, may indeed be accounted for, in a great measure, by the absence of pain or disturbed health during its progress. No warning is given to the friends of the commencement of the distortion. Without any morbid action, the spinal column, naturally weak and flexible at that age, and especially liable, when deprived of due exercise of its muscles, to have that weakness increased, yields under the superincumbent weight. Owing to the pelvis being depressed at one side in the natural attitude of standing, the spine gives way at its lower part

in the first place. A lateral curve is consequently established at the basis of the pillar ; but the existence of this curvature is not observed for some time. The deviation is so slight, that it is hidden by the dress worn by girls ; the folds of the frock conceal it ; and the mother seldom discovers that her daughter is distorted, till the effects are seen in the uncovered shoulders, one of which is observed to be higher than the other. I need scarcely, however, say, that this inequality between the shoulders proves that a second curvature has formed in the spine, higher up than the first ; that whereas the deformity consisted at first of a mere inclination of the column to one side, at a part which, from its flexibility, is easily restored to its original straightness by appropriate treatment, it has now extended to the dorsal region, involving the ribs in the distortion, and thereby rendering the cure tenfold more difficult.

From what has been said in the text, as to the actions taking place in the production of lateral curvature, we may readily understand how it should proceed through all its stages unaccompanied with pain, or any serious derangement of health. The processes by which the bones, and other structures connected with the spine, undergo the changes of form observed in confirmed distortion, instead of being morbid, are truly natural. They are the same that are carried on usually in the economy, only modified by the particular condition of the spine. First, the weight of the upper part of the body, from falling unequally on the debilitated spine, causes the column to sink under the pressure, thereby forming particular curves. In the next place, the actions by which

every structure of the body, following a well-known law of the animal economy, has its component parts incessantly changed and renewed, continues in operation during the formation of the curvatures. Consequently, while this renewal of the constituent parts is going on, the spine and all the structures, influenced by their neighbourhood to it, become changed in their forms, and accommodated to the curves. Now, in processes of such a kind there is nothing to give rise to ill health, or to produce derangement of the functions of the spinal marrow.

I may direct attention, in passing, to two different circumstances that will assist in explaining the rapid progress with which distortion, independently of any diseased process, sometimes goes on to its worst condition, after it has got a commencement.

It has been shewn before, that one of the principal causes of the common lateral curvature was the weak condition of the bones and ligaments of the spine, resulting from the want of due exercise of the muscles generally. That between the structure of the bones and ligaments of the body, and the muscular system, a mutual relation and dependence exists, is a fact well established in physiology. In proportion as the strength of the muscles of a part is increased, the bones acquire additional hardness, and the ligaments greater toughness and power of resistance, and *vice versa.* This is an adaptation which, considering the perfection of the design of the living body, we might have expected, *a priori*, to have existed between the structures which originate the forces operating in the frame, and the parts which

sustain and withstand the effects of the impulses. Accordingly, when the muscles of the spine, from want of proper exercise, are debilitated, whether from the girl being denied the varied and lively exercises suitable to her age, or from the body being confined in tightly-laced stays, which have the effect of impeding the movements of the trunk, as well as checking the development, the vertebræ, intervertebral substances, and ligaments, degenerate in a proportionate degree. They lose their natural density and firmness, and become soft and spongy; and, consequently, both vertebræ and ligaments are converted into a condition which must dispose them to suffer rapidly from the effects of unequal pressure. But the point to which I beg to draw particular attention is this; when the deformity has actually commenced, the cause above referred to, as first inducing it, operates with increased effect in consequence of the existence of the distortion.

That such must be the case, will perhaps appear evident from the following consideration. One of the necessary results of the bones of the spine becoming displaced with reference to each other, will be to destroy, to a certain extent, their mobility. The incurvation and rotation of the vertebræ together, have the effect, not only of producing material changes in the relations of the articulating surfaces, in the numerous joints of the spine, but they cause the several processes, which in the natural form of the column move clear of each other, to strike and pitch, and thus embarrass the movements of the bones generally. Now, these impediments to the free motion of the vertebræ cannot exist without producing a wasting of the muscles and degeneration of all

the textures. The spine will be in circumstances analogous to the leg of a patient with confirmed club-foot; or, to give another illustration, to the leg of one of our peasants who has long worn the clumsy laced boot that comes above the ankle, and prevents the natural freedom of action of the joint. In both the latter cases, the motions of the ankle and foot are checked, or nearly lost; the one by the distortion, the other by the tightness, with which the foot is surrounded in the boot. The consequence of the loss of motion at the ankle-joint is, that the gastrocnemius and soleus, from being thrown out of exercise, become reduced in size to such a degree that all appearance of calf is destroyed, and the leg is of equal thickness from the knee to the foot. So it is with the spine, when its natural motions are obstructed. Its muscles, and, along with them, all the other parts entering into its formation, undergo a process of atrophy; and the consequence is, a progressively increasing aggravation of the curvatures.

The second circumstance to which I will advert, relates to the influence of a diminution in the elasticity of the spine, in accelerating the progress of this kind of distortion.

It is a fact of every day's observation, that in the progress of a common case of lateral distortion of the spine, the curvature in one part advances more rapidly than that in the other. Although, as I conceive, the curve situated in the dorsal vertebræ is always, in the true case of sigmoid curvature, formed at a later period than the curve in the lumbar region, and follows as a consequence of the latter, yet it is invariably found that the dorsal curve becomes eventually much worse than that in the loins. The spine, when

once a deviation from the straight line has commenced, yields at the dorsal region, more rapidly and extensively than it does below. This, however, is not what a comparison of the structure of the dorsal with the lumbar portion, would lead us to expect. Observing how inflexible the column of the spine is where the ribs are articulated, as contrasted with the lumbar region, we should have anticipated that the greater curve would always be found in the loins, where we enjoy naturally the most extensive motion, and where, besides, from being situated lower, a greater amount of the superincumbent weight falls than in the dorsal region. It requires, therefore, to be explained, why there should be this superior tendency in the vertebræ of the dorsal part, to become proportionately more incurvated than the lumbar vertebræ.

I consider that the difference alluded to, depends on the dorsal region having a smaller amount of elasticity than the lumbar region. It has to be remarked, that it is not against injuries inflicted from without alone, that elasticity is provided in numerous parts of the body as a safeguard to the textures. The same property is of essential service in moderating the power of some of the vital actions, under certain circumstances. This may be exemplified, with regard to the process of absorption, by what is observed in aneurism. When an aortic aneurism in contact with the spine, causes a part of the column to be removed by absorption, from its pressure and pulsation conjointly, the hard bone yields before the fibro-cartilages ; and the only explanation which this fact seems to admit of is, that whereas the osseous part offered

an unyielding or dead resistance to the compression of the tumour, the intervertebral substances, by their elasticity, recoiled in correspondence with the pulsations, thereby diminishing the actual force of compression. We may suppose that there is something similar to this, in the way that pressure acts upon the incurvated spine, in the dorsal and the lumbar divisions. It is the compression caused by the superincumbent weight, that gives rise to increased absorption taking place on those sides of the vertebræ, towards which the body leans. Now, as the lumbar division is more elastic than the dorsal, chiefly on account of the greater thickness of the fibro-cartilages between the vertebræ, it may be understood why pressure will produce more remarkable effects in the dorsal division than in the lumbar. The superincumbent weight will bear upon the dorsal vertebræ, like a dead force, in steady uninterrupted operation; that is, in a way to promote the process of absorption to the greatest extent, while it will be resisted and moderated in the lumbar region by the resilience opposing it, and the absorption will be proportionately less active.

These two circumstances, taken together, appear to account satisfactorily, for what is otherwise difficult to understand, namely, how the dorsal division, the most rigid, inflexible, and apparently the strongest part of the column, when once a deviation has commenced, should yield so rapidly and extensively under the weight of the body, and present finally so much greater a degree of distortion than is observed in the lumbar region.

NOTE VI.

THE STATE OF THE SPINAL CORD.

During the changes described in the text, this organ undergoes an incurvation and a twisting of its substance in a spiral direction, corresponding with the distortion of the spine. Now, an accommodation of the shape of the cord, of such a kind, cannot be effected without certain portions suffering, to a greater or less degree, from the same processes of absorption which act upon the vertebræ and other structures. For example, at that part of the column where the sides of the vertebræ and intervertebral cartilages have been extensively removed by absorption, forming an acute bend, the spinal marrow, in order that its shape may correspond with the turn in the vertebral canal, must be absorbed in a proportionate manner on one side more than the other; consequently, a difference will exist at that point in the relative size of the two sides of the cord. Observing the roots of the nerves, it will be found that the spaces between each, owing to the contracted size of the spinal marrow at the concavity, will measure less on the concave than on the convex side. Hence the conclusion is unavoidable, that in cases of lateral distortion, a certain amount of the substance of the spinal cord may be absolutely lost or subtracted from its mass, without a perceptible effect as to diminishing its natural powers.

This is a view which it appears ought not to be overlooked altogether, in studying the relative functions of the spinal marrow and the brain.

However, the circumstances which we have noticed are not without a parallel in the brain. It is familiar to pathologists, that if pressure be applied upon the brain, and be so directed that it increases gradually and slowly, the effects will be very different, as regards the functions of the organ, from what they would have been had the pressure been suddenly applied. This fact is exemplified in the growth of tumours within the skull. Observation would shew that there is scarcely any part of the brain, however important its supposed function, that may not be compressed to the effect of losing a visible portion of its substance by absorption, without cerebral symptoms manifesting themselves,—that is, if the tumour, as it developes itself, encroaches on the brain slowly, and does not excite inflammation. It is to be presumed that it is upon an analogous principle, and because the changes are wrought gradually and without morbid action, that the spinal marrow can undergo the remarkable modifications of its form which we have described, without impairing its functions.

Aching pains, like stitches in the side, or of a dull constant kind, are sometimes felt by patients affected with lateral curvature. These, I have occasionally been led to think, might originate from the spinal nerves suffering compression at the holes through which they escape from the vertebral canal. Considering that the ganglions belonging to the sensitive roots are lodged in these foramina, and that the openings are narrowed at the concave sides of the curvatures by the approximation of the vertebræ, it naturally suggests itself that these swellings may occasionally be compressed,

by the edges of the bones; and knowing that these ganglions belong to the roots of sensation, we should expect, in such circumstances, that severe pain would be the consequence. I must admit, however, that although I have long had that hypothetical explanation of the pains in question in my mind, while observing cases of distortion, I have not been satisfied that it was a frequent cause of suffering. It has appeared that the pains referred to, depended rather on the overstraining of the ligaments of the spine, or on pressure of the displaced ribs upon adjoining parts, the natural consequences of the superincumbent weight bearing excessively on the distorted bones.

NOTE VII.

ON CUTTING THE MUSCLES OF THE BACK FOR THE CURE OF CURVATURE OF THE SPINE.

Some weeks ago I was requested by a medical friend to visit with him a patient affected with lateral curvature of the spine, as he thought that the case was one in which it might be proper to practise the new operation of dividing the muscles of the back by subcutaneous incision.

I found a girl about seventeen, who had distortion of uncommon appearance. Asking my friend to point out the particular muscles which he designed to cut, he drew his finger along th space between the base of the scapula and vertebral column on the right side,—that is, on the convex side of the upper curve—and said that he meant to divide

the portions of the trapezius in that situation, and the rhomboideus major and rhomboideus minor.

Since that time I have perused certain communications to a medical journal,* which explain in some degree the origin of my friend's proposal. Previous to that, I was at a loss to conceive what could be the rationale of his projected operation.

It appears that, at least in two distinct cases, the muscles above-mentioned, namely, a part of the trapezius and the whole of the two rhomboidei muscles, have been divided by surgeons in this country for the cure of lateral curvature. The reader may therefore be curious to learn the principle which could have suggested such an operation.

The theory is one which was first broached, if I mistake not, by Lachaise, and was afterwards espoused by Marjolin. It is to the effect that lateral curvature of the spine begins by a deviation from the straight line at the dorsal region, produced by inordinate contraction of the muscles passing between the right scapula and the spine. Owing, it is alleged, to the right hand being used in the common occupations of life more frequently than the left, the muscles of the right extremity, situated on the back, acquire such a predominating strength, as compared with those of the left side, that the trapezius, together with the two rhomboidei of the right side, have the power to draw the dorsal vertebræ to which they are attached in the direction of the scapula, and thus give rise to curvature of the spine at that part. In

* See London Medical Gazette, vols. xxvii. xxviii.

corroboration of their statement, they dwell particularly on the fulness and prominence of the right shoulder, as contrasted with the flattened condition of the left, which they consider evidences of the muscles of the right being in a a state of hypertrophy, and those of the left in a state of atrophy.

Such being the foundation of their theory of the formation of lateral distortion, it has been concluded, that, if they cut across with the knife the trapezius and rhomboidei muscles, situated on the convex side of the curvature, the column would gradually be restored to the straight position, through the operation of the corresponding muscles of the left side of the body, which would draw it towards the left.

It is not very easy to argue against a theory abounding in so many untenable positions.

1*st*, The greater fulness about the right scapula, which they ascribe to increased size of the muscles, results altogether from the position of the ribs, which, by their elevation and bulging, throw out the scapula and its muscles beyond their natural level.

2*dly*, Was there ever such an extraordinary error committed, as to suppose that if the trapezius and the two rhomboidei did act with inordinate power, the effect of their contraction would be to drag the vertebral column towards the scapula? Is it not manifest, that, owing to the loose manner in which the scapula lies on the ribs, and the rigidity of the dorsal part of the spine, the latter would be the fixed point, and the scapula would be dragged towards the spine?

3dly, Did any of the operators ever see a specimen of lateral distortion in a museum? According to the theory, it would follow, that, as the muscles referred to, pass from the scapula to the *spinous processes* of the dorsal vertebræ, these processes would be pulled by the action of the muscles in the direction of the right scapula, the supposed fixed point, or, in other words, would point towards the convexity of the curve. But such a position of the spinous processes was never seen in any preparation of lateral distortion. It is invariably found, that, in consequence of the rotation of the vertebral column on its long axis, which takes place simultaneously with its incurvation laterally, the points of the spinous processes are directed to the *concave* side of the curve.

FINIS.